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ESA CryoVEx 2012

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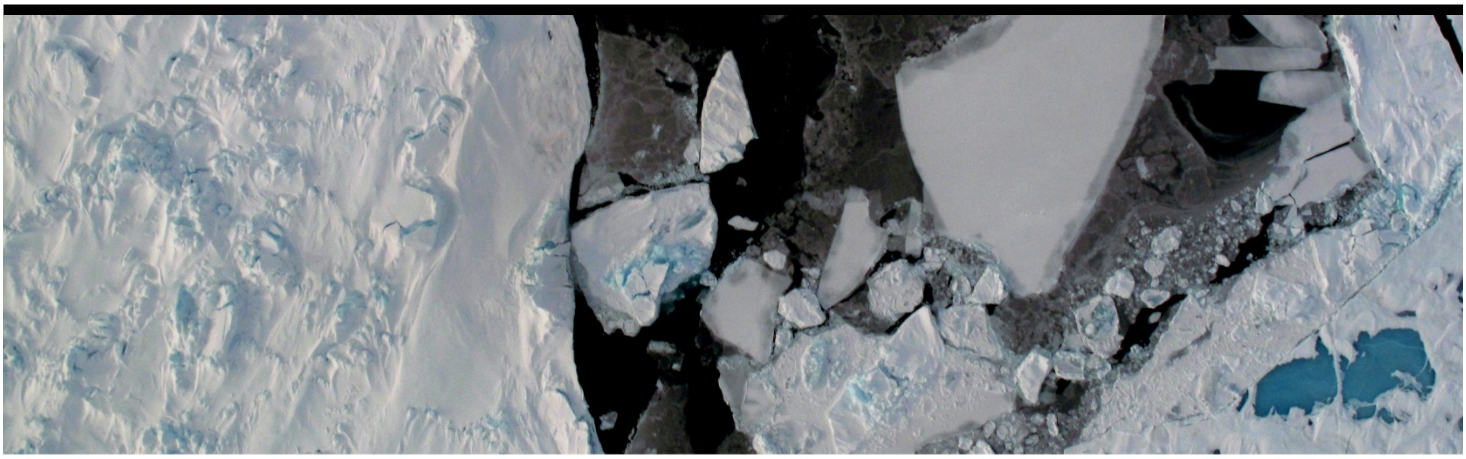

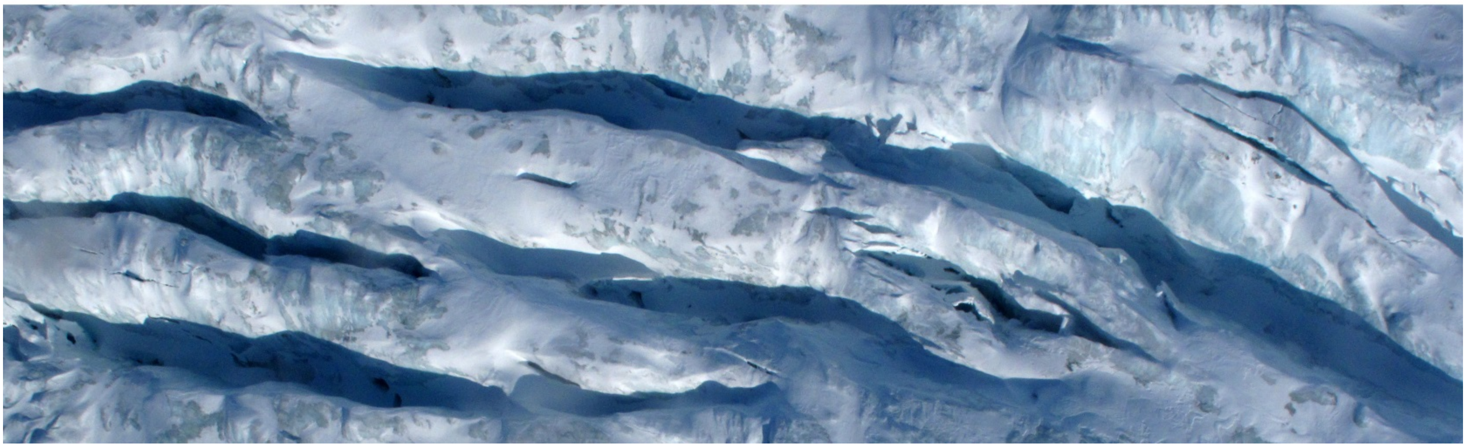

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DTU Space
National Space Institute
Technical University of Denmark

Technical Report No. 2, 2013

EUROPEAN SPACE AGENCY CONTRACT REPORT

ESA Contract No. 4000104786/11/NL/CT/fk

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Airborne field campaign with ASIRAS radar, EM induction sounder and laser scanner

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ABSTRACT

This report describes the airborne part of the Arctic CryoSat Validation Experiment (CryoVEx) 2012, which took place in the period March 25 – May 5, 2012, and includes; 1) Data collected with the ESA airborne Ku-band interferometric radar (ASIRAS), coincident airborne laser scanner (ALS) and vertical photography to acquire data over sea- and land ice along CryoSat-2 ground tracks. The airborne campaign was coordinated by DTU Space using the Norlandair Twin Otter (TF-POF). 2) Sea ice thickness data obtained with an airborne electromagnetic (AEM) induction sounder conducted by Alfred Wegener Institute (AWI) with fixed-wing airplane (Polar-5, Basler BT-67). The airborne systems are described in detail, together with campaign implementation plan, data processing and data quality analysis.

The CryoVEx 2012 campaign was a success and the processed data is of high quality. The data set includes 16 CryoSat underflights covering distances from 81-523 km. Of these, eight tracks were measured over sea ice north of CFS Alert, north of Station Nord and north of Svalbard to acquire data in areas representing different sea ice types and settings. Parts of the flights north of CFS Alert were coordinated with NASA Operation IceBridge P-3 carrying a variety of instruments for sea ice and snow retrieval. In addition, a special effort was made to acquire data in the “Wingham Box” off Canada, where CryoSat-2 is switched from SAR mode typically used over sea ice to SARIn mode.

Land ice measurements were acquired over the Greenland ice sheet (the EGIG line and selected CryoSat-2 ground tracks), together with Austfonna and Devon ice caps. At Austfonna and Devon ice caps ground teams measured ice and snow properties, and raised corner reflectors acting as a surface reference point to estimate the penetration depth of the ASIRAS radar. Unlike previous CryoVEx campaigns no ground teams were located on the Greenland ice sheet, but airborne measurements are still important to monitor changes in the ice sheet mass balance.

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NAME OF ESA STUDY MANAGER	**ESA BUDGET HEADING**
Malcolm Davidson Mission Science Division Validation Campaigns - ESTEC	

Contents

1 Introduction

In continuation of the CryoSat-2 Validation Experiment (CryoVEx) carried out in 2011, the European Space Agency (ESA) initiated a second Arctic post-launch campaign in 2012 to further calibrate and validate CryoSat-2 data products. The main purpose of CryoVEx 2012 was to acquire data along transects of CryoSat-2 ground tracks through a coordinated major effort involving a large group of European, Canadian and US scientists.

This report focuses primarily on:

1. Data collected with the ESA airborne Ku-band interferometric radar (ASIRAS), coincident airborne laser scanner (ALS) and vertical photography to acquire data over sea- and land ice along CryoSat-2 ground tracks. The airborne campaign was coordinated by DTU Space using the Norlandair Air Twin Otter (TF-POF), which is the same aircraft as used in former CryoVEx campaigns.
2. Sea ice thickness data obtained with airborne electromagnetic (AEM) induction sounding conducted with a fixed-wing airplane (Polar-5, Basler BT-67) of the Alfred Wegener Insitute.

The sea ice measurements were planned to take place in the Lincoln Sea using CFS Alert as base, but also to include flights north of Svalbard and north of Station Nord, Greenland, to acquire data over different sea ice types. Part of the flights in the Lincoln Sea was coordinated with NASA P-3 carrying a variety of instruments for sea ice and snow retrievals. A special effort was made to acquire data in the “Wingham Box” off Canada, which is an area where CryoSat-2 is switched from SAR mode typically used over sea ice to the SARIn mode.

Land ice measurements were acquired over the Greenland ice sheet (the EGIG line and selected CryoSat-2 ground tracks), together with Austfonna and Devon ice caps. At Austfonna and Devon ice caps ground teams measured ice and snow properties, and raised corner reflectors acting as a surface reference point in order to estimate the penetration depth of the ASIRAS radar. Unlike previous years no ground teams were located on the Greenland ice sheet.

An overview of the ground tracks of the airborne campaign are presented in Figure 1. For a more detailed description, the CryoVEx 2012 campaign objectives are outlined in the ESA Arctic Campaigns 2012, Campaign Implementation Plan (editors: T. Pearson, M. Wooding).

This report outlines the airborne field operations and the processing of the data acquired during the CryoVEx 2012 campaign. In addition, examples from the processed datasets are presented, together with first results of intercomparison of CryoSat-2 and airborne data.

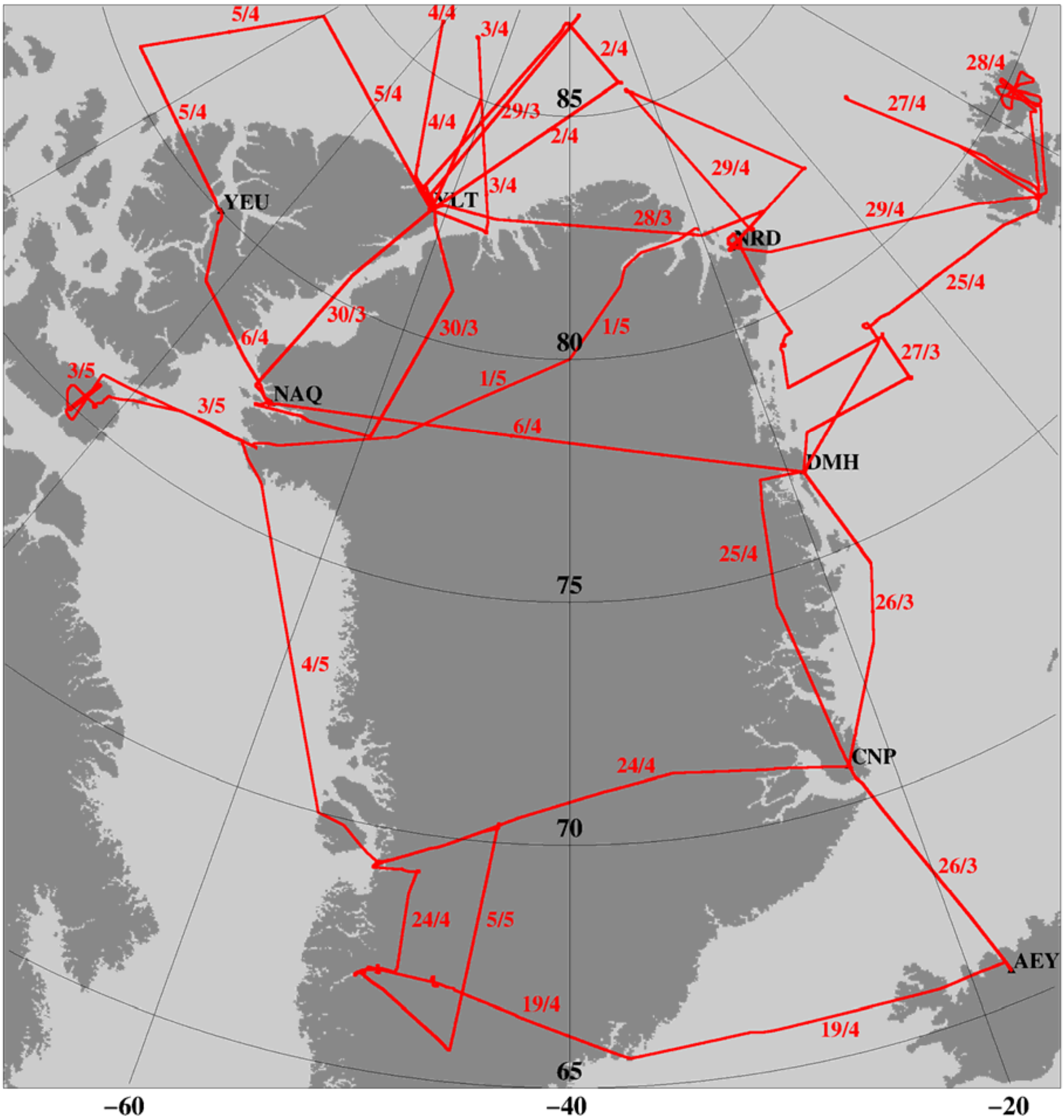


Figure 1: Overview of the flight tracks (red lines) from the CryoVEx 2012 airborne campaign. Dates of the respective flights are marked next to the flight lines.

2 Summary of operation

The CryoVEx 2012 airborne campaign was split into two operational periods. The sea ice activities in the Lincoln Sea were planned to take place early in the season to make sure the weather was stable (fog had delayed many flights in earlier pre-launch CryoVEx campaigns) and to ensure cold conditions of the sea ice itself (target temperatures of -20^{o}C and below). Thus, access to CFS Alert and Eureka was organized on March 28 – April 6. The second part of the campaign was carried out on April 23 – May 6, mainly to cover the Greenland ice sheet, Austfonna and Devon ice caps, but also the sea ice north of Svalbard and Station Nord.

A Norlandair Twin Otter (reg: TF-POF) was chartered for the entire campaign, which is the same aircraft as used throughout previous CryoVEx campaigns. The instrument certification for the aircraft was obtained in 2006 (Hvidegaard and Stenseng, 2006). The flight altitude is typically 300 m limited by the range of the laser scanner with a nominal ground speed of 135 knots. The speed can be decreased to about 110 knots, which is necessary in connection with formation flights with AWI Polar-5 when flying the EM-bird; however the relative low speed results in an increase of the pitch by a few degrees. The aircraft is equipped with an extra ferry tank permitting longer flights (5-6 hrs), and an autopilot for better navigation accuracy. In good conditions the across-track accuracy is down to a few meters using a custom-made navigation system connected to geodetic GPS receivers.

The installation of the ASIRAS radar and laser scanner (ALS) took place in Akureyri, Iceland, and Kangerlussuaq respectively. The main installation and test of ASIRAS were performed by experienced staff from Radar System Technique (RST).

First part of the campaign was based out of CFS Alert. Five CryoSat-2 ground tracks were flown over the sea ice (March 29-April 4) and on transit flight from CFS Alert to Eureka (April 5) a CryoSat-2 ground track was flown in the "Wingham box", which is an area where CryoSat-2 are switched from SAR mode typically used over sea ice to the SARIn mode. Parts of the flights was coordinated to be coincident with Alfred Wegener Institute Polar-5 towing an electromagnetic sounder (AEM) and NASA's IceBridge P-3 carrying multiple sensors for sea ice and snow retrievals. A more detailed overview is given in Section 6.1.

Second part of the campaign primarily covered the land ice. The EGIG line crossing the Greenland ice sheet from East to West at about 70^{o}N was flown on April 24 and a CryoSat-2 ground track crossing the inner parts of the Greenland ice sheet was flown on May 5 in marginal conditions. The local ice caps Austfonna and Devon were flown on April 28 and May 3, respectively. Flights on the ice caps (Devon and Austfonna) were coordinated with scientists taking measurements on the ground along CryoSat-2 ground tracks and transects of special glaciological interest, see Section 6.2. Unlike previous CryoVEx campaigns no *in situ* measurements were taken along the EGIG line, but airborne measurements are still important to monitor changes in the ice sheet mass balance. To acquire measurements of different sea ice types, CryoSat-2 tracks were flown north of Svalbard on April 27 and north of Station Nord on April 29.

In general, the weather was excellent and most of the transit flights were used to collect additional data. This includes:

- Flights in the Fram Strait to repeat flight tracks from 2006, 2008, and 2011, together with overflight of four upward looking sonar (ULS) buoys for validation of freeboard to thickness conversion, as part of the Greenland Climate Research Center research program.
- Flights with coincident ALS and P-band radar in Denmark Strait and the Greenland Ice Sheet.
- Measurements in Qaanaaq Fjord to support the Qaanaaq Fjord Experiment by Scottish Association for Marine Science (SAMS) and Danish Meteorological Institute (DMI).
- Measurements of Kongsvegen glacier in Svalbard and additional flights over the Greenland Ice Sheet.

Calibration flights of the instruments over buildings and runways were performed whenever possible. Corner reflectors were erected by the end of the runway in CFS Alert and along flight tracks on Austfonna and Devon ice caps to be used as reference point to estimate penetration depth and potential time shifts of the ASIRAS radar. For a more detailed description see Section 5.3.

The DTU Space part of the CryoVEx 2012 campaign ended officially on May 6 in Kangerlussuaq after 112 airborne hours. The flight tracks are shown in Figure 1 and a list of the flights are shown in Table 1. A day-to-day overview is given in Section 2.1 and operator logs and plots of flight tracks are provided in Appendix 1.

A total of 16 CryoSat-2 ground tracks were flown, covering distances from 81-523 km. Over the sea ice most tracks were measured both ways, in order to obtain a precise estimate of the ice drift. Whenever possible the tracks were timed to match the CryoSat-2 passage times, however this was hampered by limited airport opening hours, e.g. CFS Alert. A more detailed description of the operations of the validation sites with examples, are given in Chapter 6.

The CryoVEx 2012 campaign was a success and the CryoVEx team now has a collection of unique measurements to analyze.

Between the CryoVEx campaigns the aircraft was used to support ESA's IceSAR campaign. The overall objective of the IceSAR 2012 campaign is to demonstrate and document the potential of the BIOMASS satellite mission to monitor ice motion and subsurface structure using an airborne version of the P-band radar (POLARIS). The IceSAR campaign were split into three periods; A test flight in Iceland on March 20-23, flights over the Greenland Ice Sheet from Kangerlussuaq on April 20-22, which were repeated on May 8-9 to simulate repeat tracks of the BIOMASS satellite. An overview of the IceSAR campaign is included in the day-2-day description, as some of the installation took place coincident with the CryoVEx 2012 campaign.

The airborne team consisted of Henriette Skourup (HSK), Rene Forsberg (RF), Arne V. Olesen (AVO), Sine M. Hvidegaard (SMH), Indriði Einarsson (IE), Johan Nilsson (JN) assisted by Harald Lentz (HL) from Radar System Technique (RST) during the ASIRAS installation. Robert Ricker (RR) from Alfred Wegener Institute participated during the flights at Svalbard to be trained in operation of the ASIRAS radar. Jørgen Dall (JD) and Anders Kusk (AK) were responsible for the IceSAR program.

Table 1: Overview of CryoVEx 2012 flights. Flights along CryoSat-2 tracks and CryoVEx validation sites are highlighted by blue.

Date	DOY	Flight	Track	Take off UTC	Landing UTC	Airborne time	Airborne accumulated	Survey operator
25-03-2012	85		Testflight	11:01	11:38	37 m	37 m	HSK/AVO/HL
26-03-2012	86	a	AEY-CNP	11:22	13:30	2 hrs 08 m	2 hrs 45 m	No survey
26-03-2012	86	b	CNP-K1-K2-DMH	14:04	17:01	2 hrs 57 m	5 hrs 42 m	HSK/AVO/RF
27-03-2012	87		DMH-K17-K18-K19-K20-TOB-STN	11:05	15:57	4 hrs 52 m	10 hrs 34 m	HSK/AVO/RF
28-03-2012	88		STN-YLT	13:02	16:44	3 hrs 42 m	14 hrs 16 m	HSK/AVO/RF
29-03-2012	89		YLT-C10462-CAL-YLT	12:15	17:01	4 hrs 46 m	19 hrs 02 m	HSK/AVO/RF
30-03-2012	90	a	YLT-C10491-NAQ	12:05	14:54	2 hrs 49 m	21 hrs 51 m	HSK/AVO/RF
30-03-2012	90	b	NAQ-C10505-YLT	15:41	19:19	3 hrs 38 m	25 hrs 29 m	HSK/AVO/RF
02-04-2012	93		YLT-C10520-C10524-CR-YLT	12:04	17:29	5 hrs 25 m	30 hrs 54 m	HSK/AVO/MD
03-04-2012	94		YLT-C10540-CR-YLT	14:01	18:34	4 hrs 33 m	35 hrs 27 m	HSK/AVO/RF
04-04-2012	95		YLT-C10555-YLT	15:46	19:50	4 hrs 04 m	39 hrs 31 m	HSK/AVO/MD
05-04-2012	96		YLT-C10565-YEU	15:28	20:51	5 hrs 23 m	44 hrs 54 m	HSK/AVO/MD
06-04-2012	97	a	YEU-NAQ	14:58	16:44	1 hrs 46 m	46 hrs 40 m	No survey
06-04-2012	97	b	NAQ-DMH	17:33	21:38	4 hrs 05 m	50 hrs 45 m	HSK/AVO/RF
07-04-2012	98	a	DMH-CNP	09:16	11:45	2 hrs 29 m	53 hrs 14 m	HSK/AVO/RF
07-04-2012	98	b	CNP-AEY	12:19	14:51	2 hrs 32 m	55 hrs 46 m	HSK/AVO/RF
19-04-2012	110	a	AEY-IceSAR-KUS	11:24	14:31	3 hrs 07 m	58 hrs 53 m	HSK/JD/AK
19-04-2012	110	b	KUS-IceSAR-SFJ	15:40	18:31	2 hrs 51 m	61 hrs 44 m	HSK/JD/AK
24-04-2012	115	a	SFJ-PROMICE-JAV	10:30	12:42	2 hrs 12 m	63 hrs 56 m	SMH/HSK/JN
24-04-2012	115	b	JAV-EGIG-CNP	13:17	17:44	4 hrs 27 m	68 hrs 23 m	SMH/HSK/JN
25-04-2012	116	a	CNP-B-DMH	14:55	17:50	2 hrs 55 m	71 hrs 18 m	SMH/HSK/JN
25-04-2012	116	b	DMH-K19-ULS-LYR	18:33	22:22	3 hrs 49 m	75 hrs 07 m	SMH/HSK/JN
27-04-2012	118		LYR-C10885-LYR	15:01	19:15	4 hrs 14 m	79 hrs 21 m	SMH/HSK/RR
28-04-2012	119		LYR-AUSTFONNA-LYR	09:14	13:42	4 hrs 28	83 hrs 49 m	SMH/HSK/RR
29-04-2012	120	a	LYR-KONGSVEGEN-EN8-EN7-FI-CAL-STN	10:50	14:08	3 hrs 18 m	87 hrs 07 m	SMH/HSK/IE
29-04-2012	120	b	STN-C10915-STN	15:46	20:51	5 hrs 05 m	92 hrs 12 m	SMH/HSK/IE
01-05-2012	122		STN-H-ICE-TAB	12:10	17:23	5 hrs 13 m	97 hrs 25 m	SMH/HSK/IE
03-05-2012	124		TAB-DEVON-TAB	13:44	18:34	4 hrs 50 m	102 hrs 15 m	HSK/IE
04-05-2012	125		TAB-JAV	13:14	17:43	4 hrs 29 m	106 hrs 44 m	HSK/IE
05-05-2012	126		JAV-C11098-SFJ	11:32	16:09	4 hrs 37 m	111 hrs 21 m	HSK/IE
Total							**111 hrs 21 m**	

2.1 Day to day

March 19	Scientists Copenhagen to Akureyri, Iceland
March 20-23	IceSAR campaign installation and test flight, Akureyri, Iceland
March 24	Installation of laser scanner and ASIRAS
March 25	Testflight and measurement of runway and calibration building by GPS
March 26-28	Transit flight Akureyri to CFS Alert via Danmarkshavn and Station Nord. Sea ice measurements in Fram Strait as part of GCRC research program. No survey from Station Nord to CFS Alert due to moisture on the inside of the laser scanner
March 29	Flight along CryoSat-2 track 10462 near coincident with NASA P-3. No AEM flight with Polar-5, due to problems with the AEM
March 30	Return flight to Qaanaaq to pick up Malcolm Davidson, ESA. Flight along CryoSat-2 track 10491 in Nares Strait and CryoSat-2 track 10505 along the Greenland ice sheet. Local survey in Qaanaaq Fjord, to support Qaanaaq Fjord field activities
March 31 – April 1	
	No flying due to restricted opening hours on CFS Alert. Corner reflector placed by the end of the runway
April 2	Flight along CryoSat-2 ground track 10520 near coincident with NASA P-3 followed by CryoSat-2 ground track 10524
April 3	Flight along CryoSat-2 ground track 10540 in formation with Polar-5
April 4	Flight along CryoSat-2 gorund track 10555 in formation with Polar-5
April 5	CFS Alert to Eureka. Survey CryoSat-2 track 10565 in “Wingham box” together with Polar-5
April 6-8	Transit flight Eureka to Akureyri via Danmarkshavn due to poor weather in Pond Inlet and west coast of Greenland. Survey transect of inland ice Qaanaaq to Danmarkshavn. Unmount instruments
April 9	Scientists Akureyri to Copenhagen
April 17	Scientists Copenhagen to Akureyri
April 18	Installation of IceSAR
April 19	Transit flight Akureyri to Kangerlussuaq via Kulusuk. Measurement over the sea ice in Denmark Strait and the Greenland Ice sheet with ALS and P-band radar (POLARIS)

April 20-22	IceSAR flights and uninstallation of P-band radar (POLARIS)
April 23	Re-installation of ASIRAS
April 24	Kangerlussuaq to Ilulissat along PROMICE track. Ilulissat to Constable Pynt along the EGIG line
April 25	Transit flight Constable Pynt to Longyearbyen via Danmarkshavn. Sea ice flight in Fram Strait including overflight of ULS buoys
April 26	No flying due to weather
April 27	CryoSat-2 track 10885 north of Svalbard
April 28	Austfonna icecap (CryoSat-2 ground tracks 11015, 11044, 11110, Eton-East, NW Hartog, ASIRAS line 472)
April 29	Transit flight Longyearbyen to Station Nord. Survey Kongsvegen, Fram Strait sea ice and Flade isblink. Calibration flight of building and runway at Station Nord. CryoSat-2 track 10915 out of Station Nord together with eastern part of triangle
April 30	No flying, Station Nord
May 1	Transit flight Station Nord to Thule AB
May 2	No flying due to technical issues (the electrical system) with the aircraft
May 3	Devon ice cap flight (CryoSat-2 ground tracks 10976 and 10810, line 423, line 450 and Belcher)
May 4	Transit flight Thule AB to Ilulissat conditions marginal for surveying sea ice in Baffin Bay
May 5	CryoSat-2 track 11098 over the Greenland inland ice, conditions marginal
May 6-7	Uninstallation of ASIRAS and reinstallation IceSAR
May 8-9	IceSAR campaign
May 10-11	Transit flight Kangerlussuaq to Akureyri, uninstallation of equipment in aircraft
May 12	Scientists Akureyri to Copenhagen

3 Hardware installation

The installation of the ASIRAS system was identical to the setup used throughout the CryoVEx 2011 campaign (Skourup et al, 2012), using the certification for the Twin Otter (TF-POF) acquired in 2006 (Stenseng et al, 2007). To support the ASIRAS system a Novatel GPS DL-V3 was kindly loaned from the Alfred Wegener Institute (AWI).

The ALS equipment was of type Riegl LMS Q-240i (also used in CryoVEx 2011 and 2008). To prevent malfunction of the ALS during the extreme low temperatures (-20^{o}C and below) in the first part of the campaign, the ALS was wrapped with external heater pads. In addition, an external heater fan as well as an electrical heater, were installed in the instrument bay in the rear baggage compartment of the aircraft, see Figure 6. An older version of the ALS Riegl (LMS Q-140i) was carried along as backup unit.

In addition, three geodetic dual-frequency GPS receivers were mounted for precise aircraft positioning. The receivers (AIR1, AIR2 and AIR3) were connected to two separate GPS antennas (“front” and “rear”) through antenna beam splitters. The GPS antennas are permanently installed on TF-POF. Receiver types, antenna information, as well as logging rates for the GPS receivers are given below:

- AIR1 Receiver type Javad Delta connected to front antenna with logging rate 2 Hz
- AIR2 Receiver type Javad Lexon connected to rear antenna with logging rate 5 Hz
- AIR3 Receiver type Javad Delta connected to front antenna with logging rate 1 Hz

The higher logging rate for AIR2, was chosen to obtain a higher precision for the on-board navigation system. Offsets between GPS antennas and ASIRAS/ALS are given in Table 2.

To record the attitude (pitch, roll and heading) of the aircraft, two inertial navigation systems (INS) were used. The primary unit is a medium grade INS of type Honeywell H-764G. This unit collects data both in a free-inertial and a GPS-aided mode at 50 Hz. Specified accuracy levels in roll and pitch are better than 0.1^{o}, and usual accuracy is higher than this. A backup INS is provided by an OxTS Inertial+2 integrated GPS-INS unit, with a nominal similar accuracy as the H-764G. The Honeywell INS was connected to the front GPS antenna. During most of the campaign the OxTS used single antenna setup with the rear GPS antenna as primary antenna. To test whether a dual antenna setup improves the accuracy of the OxTS INS, the setup was changed on May 1 (DOY 122) before take-off to include the front antenna as secondary antenna.

To collect high-resolution images, a camera of type Canon G-10 with remote control was mounted next to the ALS in the rear baggage compartment of the aircraft, see Figure 6, and a camera of type Canon 60D was mounted in the cabin looking out the starboard rear window to collect slant-looking images. These cameras were supplemented by slant-looking images and video taken on occasional basis using a compact system camera of type Olympus E-PL3.

The setup of the instruments in the aircraft is shown in Figure 2 and pictures of the various instruments are shown in Figure 3-7.

Table 2: The dx, dy and dz offsets for the lever arm form the GPS antennas to the origin of the laser scanner, and to the back centre of the ASIRAS antenna (see arrow Figure 2).

To laser scanner	**dx (m)**	**dy (m)**	**Dz (m)**
from AIR1/AIR3 (front)	- 3.70	+ 0.52	+ 1.58
from AIR2/AIR4 (rear)	+ 0.00	- 0.35	+ 1.42
to ASIRAS antenna	**dx (m)**	**dy (m)**	**dz (m)**
from AIR1/AIR3 (front)	-3.37	+0.47	+2.005
from AIR2/AIR4 (rear)	+0.33	-0.40	+1.845

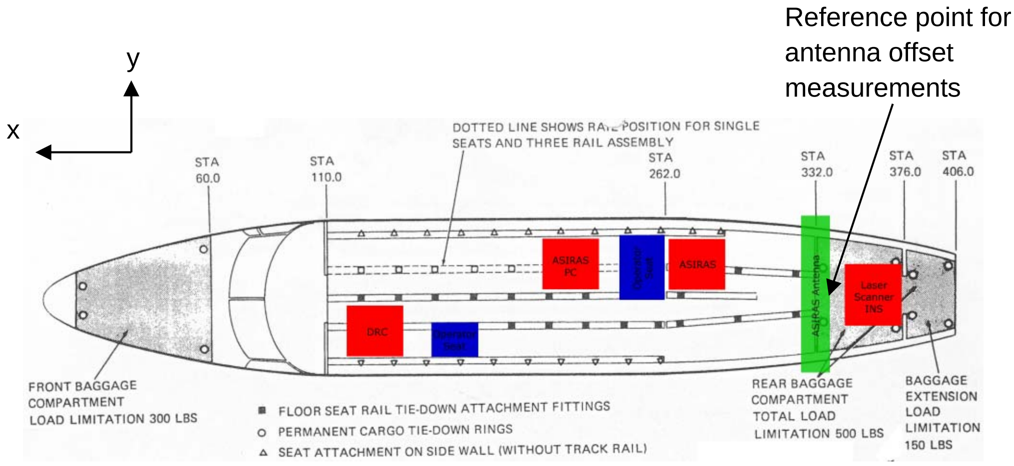


Figure 2: Overview of instrument setup in the TF-POF Twin Otter aircraft.

Figure 3: ASIRAS antenna.

Figure 4: View of cabin in aircraft; Rack with ASIRAS PC's (front right), rack for ALS, GPS and INS (rear left). Spare fuel tank for extra airborne time (front left).

Figure 5: Snapshot of ASIRAS operation display over sea ice.

Figure 6: Instrument bay in rear baggage compartment of the aircraft. In front laser scanner RIEGL LMS Q-240i with heater pads (grey/orange instrument). H-764G INS (grey box) and OXTS INS (red box) in the back. Between the two INS instruments are mounted two external heaters (small black boxes).

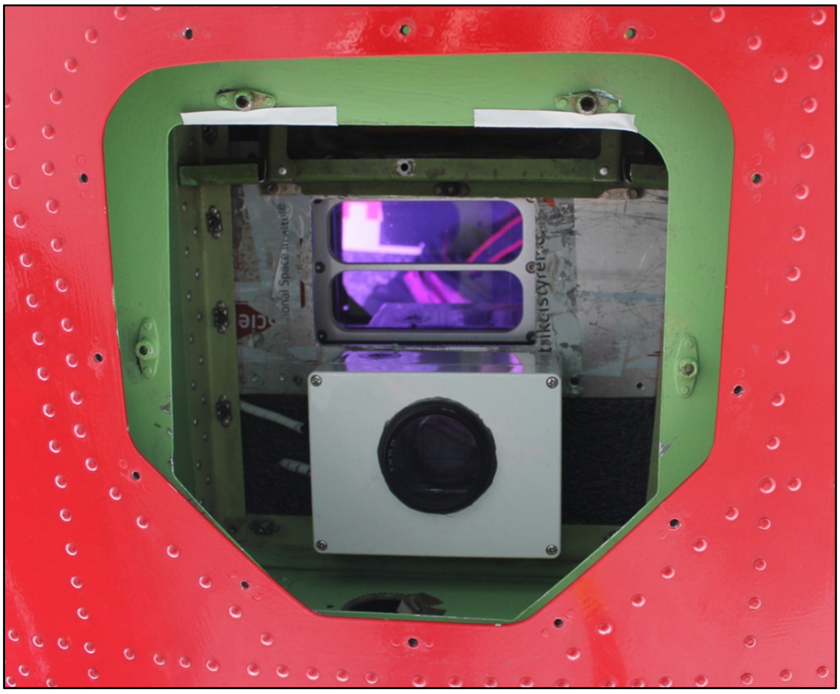


Figure 7: Photo taken from below through hole in aircraft; Visible instruments are laser scanner (purple windows) and nadir looking camera (grey box).

4 Overview of acquired data

Data acquisition of the various instruments was acquired where feasible, considering the limited height range of the ALS system and the weather. An overview of all acquired data is listed in Table 3.

All the ASIRAS data was acquired in Low Altitude Mode (LAM) with low along-track resolution (LAMa). This allows flight at an altitude of 300 m, which is within the operational range of the ALS system and a relative low data volume of about 28 GB per hour. A total 1.86 TB raw ASIRAS data were collected during the CryoVEx 2012 campaign. The data was stored on hard discs as ASIRAS level 0 raw data in the modified compressed format (Cullen, 2010) and has been shipped to the Alfred Wegener Institute (AWI) for further processing.

The ASIRAS system performed well during the campaign and the PC only crashed at two occasions:

- 04-04-2012 PC1 freezes, hard reboot (ASIRAS: A120404_00.log)
- 24-04-2012 Comm. problem with radar serial link, program restart (ASIRAS: A120424_01.log)

This only caused loss of few minutes of data before the system was up and running.

In general, the ALS worked excellent. At extreme low temperatures (below -20^{o}C), experienced through the first part of the campaign, moisture on the inside of the instrument prevented the laser to see through the instrument window. Total blocking of the laser signal was only an issue during take-off most likely due to the extreme temperature decrease caused by the acceleration of the aircraft, which caused the moisture to freeze. To circumvent the laser to lock on the frozen instrument window, the ALS was switched to measure the “last laser pulse”. It took about 30-45 minutes after take-off to heat the system to obtain full scan width. Data was only lost on the flight from Station Nord to CFS Alert on March 28 (DOY 88) and the first 20 minutes of the flight on March 29 (DOY 89) due to freezing of the moisture. After the end of the campaign the ALS was shipped to Riegl to be dried out.

The data volume obtained by the ALS is about 250-300 MB an hour which is a relative small amount, when compared to the ASIRAS data volume. During the campaign a total of 26.2 GB ALS data were acquired.

The airborne GPS units logged data internal in the receivers (AIR1, AIR2 and AIR3) during flight, which were downloaded upon landing on laptop PCs. The Novatel GPS was dedicated to support ASIRAS and was not part of the logging system. GPS files were recovered for all receivers at all flights, except on May 1 (DOY 122), where AIR3 was started 20 min. after take-off, as the antenna cable had been unplugged during the reconfiguration of the OxTS INS antenna setup. The GPS reference stations listed in Table 3 are described in further detail in Section 5.1.

Both INS systems logged continuously throughout the campaign and no problems were observed with the systems. Due to operator handling, logging of the Honeywell INS was started late on March 26 (DOY 86) and the OxTS INS was stopped during the flight on March 28 (DOY 88).

Vertical photography was collected during flights primarily to support the analysis of ALS data over sea ice. Pictures were acquired every 3-4 seconds for most flights by nadir and slant-looking photography.

All data are stored on external hard discs, as well as the DTU Space servers with tape backup system.

Figure 8: Photo of Norlandair Twin Otter (TF-POF) at CFS Alert. Photo: M.Davidson (ESA).

Table 3: Overview of data.

Date	DOY	AIR1	AIR2	AIR3	INS H-764G	INS OxTS	ALS	ASIRAS	GPS REF1	GPS REF2	GPS REF3	Photos nadir	Photos slant	Log
25-03-2012	85	X	X	X	X	X	X	LAMa	AEY1	AEY2				X
26-03-2012	86A	X	X	X	X	X	X[1)]							X
26-03-2012	86B	X	X	X	X[2)]	X	X	LAMa						X
27-03-2012	87	X	X	X	X	X	X	LAMa						X
28-03-2012	88	X	X	X	X	X[3)]		LAMa			STN3			X
29-03-2012	89	X	X	X	X	X	X[4)]	LAMa	YLT1		STN3		X	X
30-03-2012	90A	X	X	X	X	X	X	LAMa	YLT1		STN3		X	X
30-03-2012	90B	X	X	X	X	X	X	LAMa	YLT1		STN3		X	X
02-04-2012	93	X	X	X	X	X	X	LAMa	YLT1		STN3		X	X
03-04-2012	94	X	X	X	X	X	X	LAMa	YLT1		STN3		X	X
04-04-2012	95	X	X	X	X	X	X	LAMa[5)]	YLT1		STN3		X	X
05-04-2012	96	X	X	X	X	X	X	LAMa		YEU2	STN3		X	X
06-04-2012	97A	X	X	X							STN3		X	X
06-04-2012	97B	X	X	X	X	X	X	LAMa			STN3			X
07-04-2012	98A	X	X	X	X	X					STN3		X[6)]	X
07-04-2012	98B	X	X	X							STN3		X[6)]	X
19-04-2012	110A	X	X	X	X[7)]	X	X				STN3			X
19-04-2012	110B	X	X	X	X[7)]	X	X				STN3			X
24-04-2012	115A	X	X	X	X	X	X	LAMa[8)]			STN3			X
24-04-2012	115B	X	X	X	X	X	X	LAMa			STN3			X
25-04-2012	116A	X	X	X	X	X	X	LAMa			STN3	X[9)]		X
25-04-2012	116B	X	X	X	X	X	X	LAMa			STN3	X[9)]		X
27-04-2012	118	X	X	X	X	X	X	LAMa	LYR1	LYR2	STN3	X		X
28-04-2012	119	X	X	X	X	X	X	LAMa	LYR1	LYR2	STN3	X		X
29-04-2012	120A	X	X	X	X	X	X	LAMa			STN3	X		X
29-04-2012	120B	X	X	X	X	X	X	LAMa	STN1	STN2	STN3	X		X
01-05-2012	122	X	X	X[10)]	X	X	X	LAMa				X		X
03-05-2012	124	X	X	X	X	X	X	LAMa	TAB1	TAB2		X		X
04-05-2012	125	X	X	X	X	X	X	LAMa				X		X
05-05-2012	126	X	X	X	X	X	X	LAMa						X

1) Scoresbysund only Logging started 1 hr 15 m after takeoff
2) Logging started 1 hr 15 m after take-off
3) Only 1 hr data
4) At 1300 UTC ALS set to lock on “last laser pulse”
5) Log file A120404_00.log no record stop time, PC freezing reboot
6) Not complete
7) H-764G INS different logging format (A. Kusk)
8) Comm. Problem, program restart (ASIRAS: A120424_01.log)
9) Trial version
10) GPS started 20 min after takeoff

5 Processing

The data processing is divided between DTU Space and AWI. ASIRAS data is processed by AWI using GPS and INS data supplied by DTU Space. GPS differential positioning combined INS-GPS integration is done by DTU Space followed by processing of laser distance measurement into elevation above a reference ellipsoid. This is supplemented by geo-reference of the images taken along the flights, see Section 5.5.

5.1 GPS data processing

The exact position of the aircraft is found from kinematic solutions of the GPS data obtained by the GPS receivers installed in the aircraft, see Chapter 3. Two methods have been used for post-processing of GPS data, kinematic differential (DIF) processing and precise point positioning (PPP). Whereas the first method uses information from base stations in the processing procedure, the PPP method is only based on precise information of satellite clock and orbit errors.

The GPS base stations used as reference stations for differential post processing of the GPS data are listed in Table 4. The stations were mounted on tripods or on roofs in the field near the landing sites. It is presumed that the antenna was mounted on DTU Space large tripods (vertical height 12 cm), unless otherwise stated. The reference points were generally not marked.

A semi-permanent GPS base station was established at Station Nord, which continuously logged data throughout the period March 28 to April 29. Examples of GPS base stations at Akureyri and Thule AB are shown in Figure 9.

Three different GPS receivers (REF1, REF2 and REF3) were used as base stations. Information of the receiver, antenna and logging rates are listed below:

- REF1 Receiver type Javad Maxor with internal antenna 1 Hz
- REF2 Receiver type Javad Delta with MarAnt antenna 0.1 Hz
- REF3 Receiver type Javad Delta with RegAnt antenna 0.1 Hz

The base stations listed in Table 4, are named with three letters corresponding to airport codes listed in Appendix 2, followed by a number referring to REF1, REF2 or REF3. The positions of the base stations are determined using the online GPS processing services AUSPOS (http://www.ga.gov.au/earth-monitoring/geodesy/auspos-online-gps-processing-service.html) offered by Geoscience Australia. The service calculates the position of the reference stations in the ITRF 2008 reference system using data from the closest permanent GPS stations with a position accuracy of about 2 cm. This accuracy is available even in the Arctic with long distances to the closest permanent stations. The coordinates of all the reference stations used during CryoVEx 2012 are found in Appendix 3.

Table 4: Overview of CryoVEx 2012 GPS reference stations

Name	Location	Site description
AEY1	Akureyri	Outside Norlandair hangar on grass strip between apron and runway
AEY2	Akureyri	Outside Norlandair hangar on grass strip between apron and runway
STN3	Station Nord	Antenna mounted on pole next to building 7
STN1	Station Nord	Apron next to fuel pump
STN2	Station Nord	Apron next to fuel pump
YLT1	CFS Alert	Next to apron
YEU2	Eureka	On the ground north of the "city"
LYR1	Longyearbyen	Airport next to apron
LYR2	Longyearbyen	Airport next to apron
THU1	Thule AB	Near Air Greenland hangar
THU2	Thule AB	Near Air Greenland hangar
SFJ1	Kangerlussuaq	By the fjord close to IceSAR corner reflector (20-04-2012 on grass in front of Air Greenland hangar)
SFJ2	Kangerlussuaq	By the fjord close to IceSAR corner reflector (20-04-2012 on grass in front of Air Greenland hangar)


Figure 9: GPS base stations in Akureyri (left) and Thule AB (right).

The GPS processing were performed with Waypoint GrafNav (version 8.20) by use of precise IGS orbit and clock files and correction for ionospheric and tropospheric errors. For each flight several solutions are made using different combinations of GPS reference stations and aircraft receivers. The best solution for each flight is selected according to Table 5 and used in the further processing

5.2 Inertial Navigation System

The position and attitude information (pitch, roll and heading) recovered from the raw Honeywell (H-764G) and the Oxford Inertial 2+ (OxTS) INS data at 10 Hz, are merged with the GPS solutions by draping the INS derived positions onto the GPS solutions. The draping is done by modeling the function, found in the equation below, by a low pass smoothed correction curve, which is added to the INS.

$$\varepsilon\,(t) = P_{GPS}(t) - P_{INS}(t)$$

This way a smooth GPS-INS solution is obtained, which can be used for geolocation of laser and camera observations.

No problems of INS data from the Honeywell instrument were encountered during the processing. The attitude of the backup instrument (OxTS INS) is found to have degraded accuracy during acceleration, which includes turns and rapid changes of altitude (Skourup et al, 2012). This setup uses only one GPS antenna, and a dual antenna setup was tested during the last part of the campaign, see Chapter 3.

The selected INS solutions are listed in Table 5, as seen only second part of the flights on DOY 086b and 116b are using data from the backup INS unit OxTS. These sections are primarily over long straight sections of sea ice in the Fram Strait, which are not influenced by the degraded accuracy of the OxTS instrument.

The best solutions of both GPS and INS data based on Table 5 are packed as binary files in the special ESA file format, see Appendix 7.2 and 7.3. An overview of the final GPS and INS files are listed in Appendix 8 and 9, respectively, with file name convention according to Appendix 6.

Table 5: List of best combination of GPS and INS data

Date	DOY	File name	Reference	Processing	INS	Rover
25-03-2012	085	085aey1a2.p	Aey1	DIF	H-764G	AIR2
26-03-2012	086a	086A_a3.p	None	PPP	H-764G	AIR3
26-03-2012	086b	086Ba2.p	None	PPP	H-764G/OxTS	AIR2
27-03-2012	087	087a2_ppp.p	None	PPP	H-764G	AIR2
28-03-2012	088	088nrd3a2.p	NRD3	DIF	H-764G	AIR2
29-03-2012	089	089YLT1a3.p	YLT1	DIF	H-764G	AIR3
30-03-2012	090a	090AYLT2a3.p	YLT2	DIF	H-764G	AIR3
30-03-2012	090b	090BYLT2a3.p	YLT2	DIF	H-764G	AIR3
02-04-2012	093	093YLT1a2.p	YLT1	DIF	H-764G	AIR2
03-04-2012	094	094YLT1a2.p	YLT1	DIF	H-764G	AIR2
04-04-2012	095	095YLT1a3.p	YLT1	DIF	H-764G	AIR3
05-04-2012	096	096a2_ppp.p	None	PPP	H-764G	AIR2
06-04-2012	097a	097Aa3.p	None	PPP	H-764G	AIR3
06-04-2012	097b	097Ba2_ppp.p	None	PPP	H-764G	AIR2
19-04-2012	110a	110a2A.p	None	PPP	H-764G*	AIR2
19-04-2012	110b	110a3B.p	None	PPP	Problems!	AIR3
24-04-2012	115a	115a2_A.p	None	PPP	H-764G	AIR2
24-04-2012	115b	115a2_B.p	None	PPP	H-764G	AIR2
25-04-2012	116a	116a3_A.p	None	PPP	H-764G	AIR3
25-04-2012	116b	116a3_B.p	None	PPP	H-764G/OxTS	AIR3
27-04-2012	118	118Lyr1a2.p	LYR1	DIF	H-764G	AIR2
28-04-2012	119	119Lyr1a3.p	LYR1	DIF	H-764G	AIR3
29-04-2012	120a	120Aa2.p	None/NRD3	PPP/DIF	H-764G	AIR2
29-04-2012	120b	120Bnrd1a2.p	NRD1	DIF	H-764G	AIR2
01-05-2012	122	122a2_ppp.p	None	PPP	H-764G	AIR2
03-05-2012	124	124tab1a2.p	TAB1	DIF	H-764G	AIR2
04-05-2012	125	125a2_ppp.p	None	PPP	H-764G	AIR2
05-05-2012	126	126a3.p	None	PPP	H-764G	AIR3

*From Polaris system

5.3 Airborne Laser Scanner (ALS)

The laser scanner operates with wavelength 904 nm. The pulse repetition frequency is 10,000 Hz and the ALS scans 40 lines per second, thus the data rate is 251 pulses per line. This corresponds to a horizontal resolution of 0.7 m x 0.7 m at a flight height of 300 m and a ground speed of 250 kph. The across-track swath width is roughly equal to the flight height, and the vertical accuracy is in the order of 10 cm depending primarily on uncertainties in the kinematic GPS-solutions. The raw logged files with start /stop times are listed in Appendix 4.

5.3.1 Calibration

Calibration of ALS misalignment angles between ALS and INS can be estimated from successive overflights from different directions of the same building, where the position of the corners are known with high precision from GPS measurements. These calibration maneuvers have been carried out several times as listed below:

- 25-03-2012 DOY 85 Akureyri
- 29-03-2012 DOY 89 CFS Alert
- 24-04-2012 DOY 115 Kangerlussuaq
- 29-04-2012 DOY 120 Station Nord
- 05-05-2012 DOY 126 Kangerlussuaq

The corners of a building close to the Norlandair hangar and the runway were surveyed by geodetic GPS to be included in the calibration of the ALS and ASIRAS. The measurements were measured on March 25 (DOY 85) and again on August 12 in connection with other scientific activities.

Figure 10: Map of Akureyri airport with building used for calibration marked by red circle.

The processing of the ALS data has been straightforward with the exception of one file at Austfonna ice cap. Pre-processing of the contaminated file (119_115730.2dd) reveals a systematic off-set in scanline heights, which potentially could originate from wrong input parameters to the rotating mirrors of the laser scanner. The issues are still unresolved, but will most likely be solved in the future. The calibration angles for each flights based on the calibration flights together with inspection of cross-overs and overflights of relative flat surfaces, can be found in Appendix 4.

5.3.2 Laser scanner outlier detection and removal

No major problems were encountered with the instruments. Due to the problems with moisture on the inside of the ALS (see Chapter 4), some of the flights out of CFS Alert have reduced scan width down to about 100 m. The largest effects were obtained during the first 30-45 minutes of the survey flights until the external and internal heaters had melted the ice. The scan width limits for each flight can be found in Appendix 4.

In addition, large parts of the data are contaminated by negative errors (outliers). To detect the outliers, we use a diversity of criteria. Note that we throw away rejected data without attempting to interpolate or otherwise guess missing values, since data is abundant.

Our method is based around a robust linear model. For a portion (containing L data points) of each scan-line, we estimate a best fitting polynomial model of degree N using a robust linear model (RLM) via iteratively reweighted least squares using Huber's T weighing function. The RLM estimation results in three sets of data:

- estimated polynomial coefficients. These are indeed not used at all
- estimated weights from the reweighting algorithm. These are available for each data point and are on the interval [0,1]
- residuals for each data point.

The criterion by which we accept a data point or decline it as an outlier is based on a combination of the estimated weights and the residuals. We choose a parameter $0<w_{min}<1$ and decline a measurement p_i as an outlier if the corresponding estimated weight w_i is less than w_{min}.

We also define a maximum deviation D_{max} from the estimated model. For a data point p_i, we look at the residual r_i, and decline the point as outlier if $|r\_i|>D_{max}$.

Because of the different nature of sea-ice and inland-ice, we need to use different criteria for the different kinds of ice. Sea ice seldom reaches more than a few meters above sea-level, Therefore, the highest deviances in sea ice data can be expected from icebergs, at a maximum of a few tens of meters. Thus, for sea ice, we can use a D_{max} value of 20 m. Furthermore, we use a 0th degree polynomial (constant approximation) and a relatively low w_{min} value of 0.2. This results is relatively few falsely detected outliers.

For inland ice, we cannot make as strict assumptions on the behaviour of the signal, since it can be quite dynamic due to mountains protruding the ice cap, topography underneath the ice or cracks in the ice. Therefore, we need to choose a more flexible polygonal model of degree and higher w_{min} value. For each flight over land ice the various parameters were chosen to best fit the current case, and thus varies between each flight.

5.3.3 Statistical consequences:

Due to the high data volume (few tens of gigabytes of data) the outlier-detection needs to be automatic and independent of human judgement. To prevent any outliers to get through the process undetected, a rather heavy-handed choice of filtering parameters is necessary. This of course results in a considerable amount of false positives, i.e. good data points being rejected. It is therefore worth to mentioning what effect the missing data points have.

Since the root of the outliers is within the measurement instrument rather than caused by the topography, we can assume that the correctly removed outliers have the same mean height as the remaining, correctly measured points. The falsely detected outliers, on the other hand, are likely to be extreme values in the data series, caused by real topographical features. Since we want to prevent the outlier detection algorithm from introducing biases into the data, it is important that it handles positive and negative deviances from the estimated model in the same way. This is the reason that we have chosen to ignore the fact, that the outliers evident in the data are strictly positive (i.e. the false height is higher than the surroundings). By using this seemingly useful information, we would have introduced a bias through the false positives.

The above described method is excellent to remove a few negative outliers in a given data set, but fails for clouds, as it is based on a selection procedure for each scan-line. Thus, in the case with presence of clouds (28-04-2012 and 05-05-2012) the ALS data has further been through a manual filtering procedure to filter out the clouds from the data sets.

5.3.4 Cross-over statistics

The ALS is in general of high quality with a standard deviation of cross-over differences of less than 8 cm, see Table 6, except over sea ice, where the standard deviation is increased due to drift of the sea ice. The mean of the cross-overs are less than 3 cm, except in those cases over the Greenland Ice Sheet (GrIS) where there are several days (7-25 days) between the data acquisitions. The mean is in these cases a combination of errors in the GPS solutions, together with melt and accumulation over the ice sheet. Examples of cross-over differences for Devon ice cap and over the sea ice north of Station Nord is given in Figure 11.

The processed ALS elevations can be seen in Figure 13, where missing sections are mainly due to low clouds and fog.

Processed data comes as geo-located point clouds, in lines of width 200-300 m at full resolution 1mx1m, in format time, latitude, longitude, heights given with respect to WGS-84 reference ellipsoid. The data is packed in binary data files in the special ESA format, see Appendix 7.4. An overview of the processed data is given in Appendix 10 with file name convention as listed in Appendix 6.

Table 6: ALS cross-over statistics

Date	DOY	Validation site	Mean (m)	Std. Dev (m)	Min (m)	Max (m)	# points
29-04-2012	120B	Sea ice STN	-0.03	0.14	-2.39	2.14	27,522
30-03-2012 06-04-2012	90/97	GrIS	-0.08	0.06	-0.37	0.19	19,929
06-04-2012 01-05-2012	97/122	GrIS	0.08	0.05	-0.12	0.46	46,329
24-04-2012	115A	GrIS	0.02	0.07	-0.73	0.41	35,229
24-04-2012 05-05-2012	115B/126	EGIG	0.15	0.06	-0.28	0.30	88,318
28-04-2012	119	Austfonna	-0.03	0.05	-0.73	0.18	28,225
03-05-2012	124	Devon	0.01	0.04	-0.66	0.22	28,365
			0.00	0.04	-0.17	0.21	27,019
			-0.01	0.05	-0.21	0.19	86,545
05-05-2012	126	GrIS	-0.03	0.08	-0.38	0.30	28,277

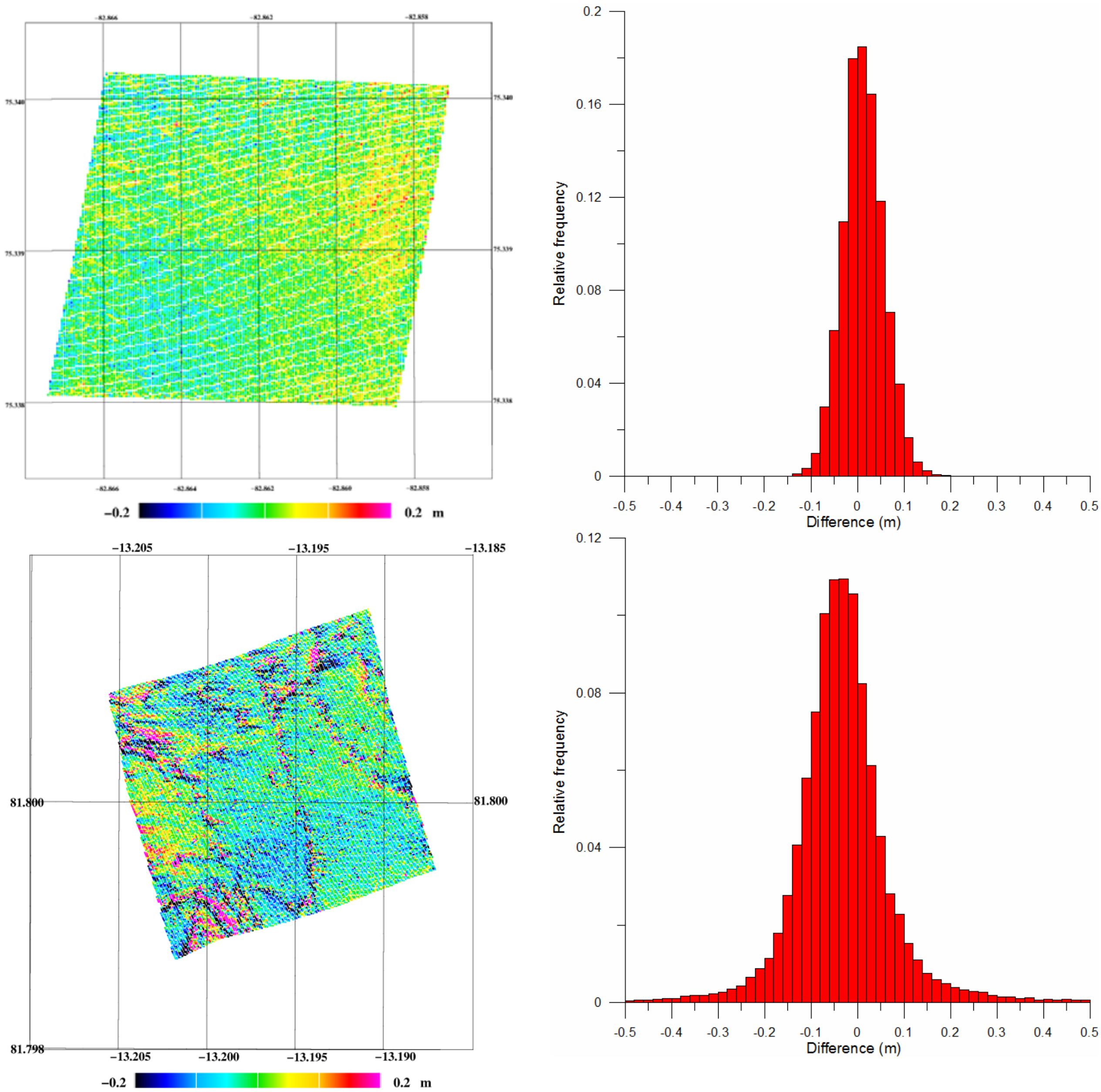


Figure 11: Cross-over differences and associated histograms from Devon ice cap (upper panel) and sea ice north of Station Nord (lower panel). The relative large differences seen in over the sea ice, is due to drift of the sea ice between data acquisition.

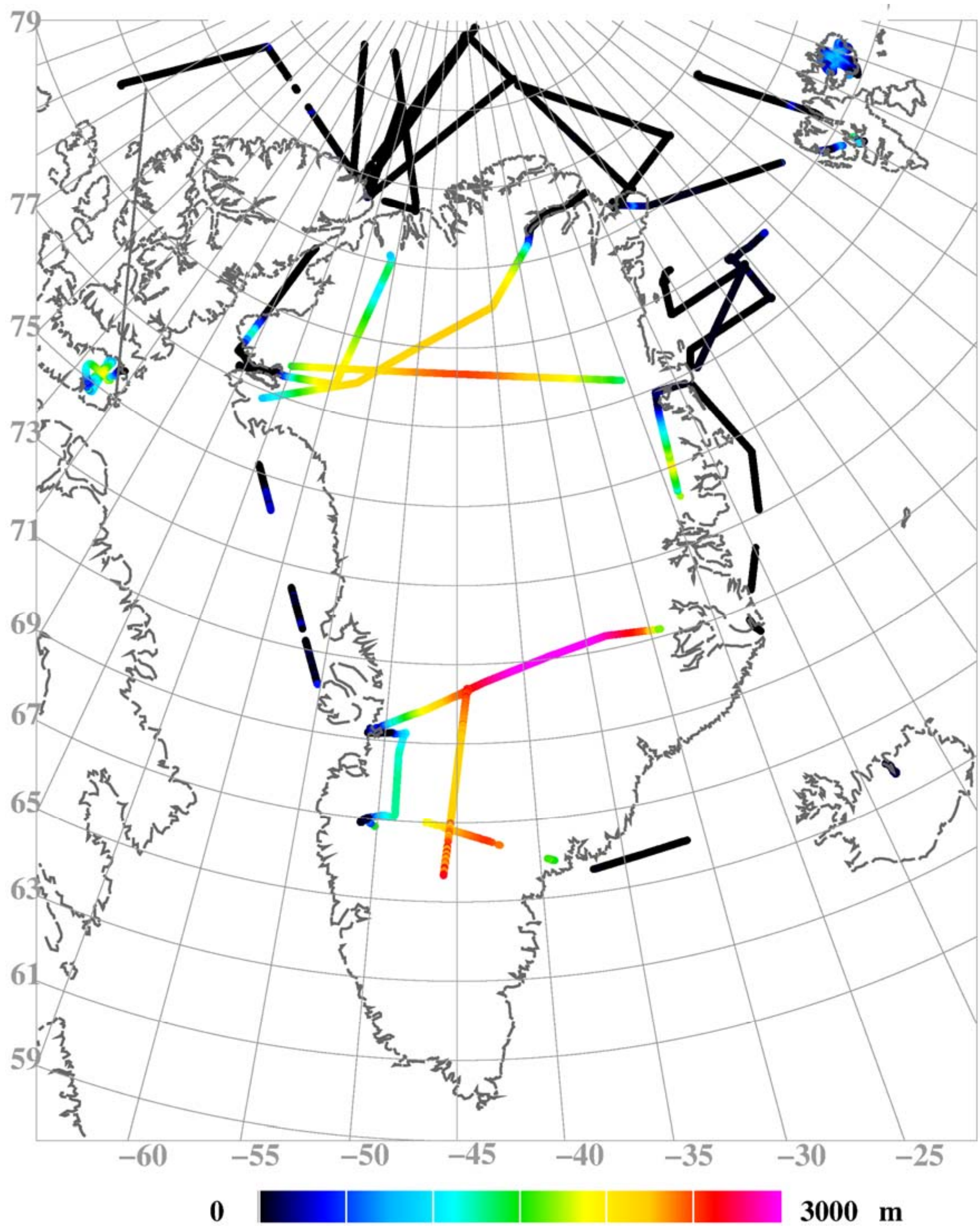


Figure 12: Processed ALS elevations wrt WGS-84 reference ellipsoid. Missing sections are mainly due to low clouds and fog.

5.4 ASIRAS

The ASIRAS radar operates at 13.5 GHz with footprint size 10 m across-track and 3 m along-track at a standard flight height of 300 m. An overview of the acquired ASIRAS log-files together with start/stop times, range window and number of pulses are listed in Appendix 5.

5.4.1 CryoVEx 2012 ASIRAS processing results

The ASIRAS processing of the CryoVex2012 data is analogous to the concepts already presented in Helm et al. (2006). The full data set was processed with ESA's processor version ASIRAS_04_03. A summary of the processing is given in Appendix 12, which shows plots of every single profile. A couple of tests were applied to address datation issues and to show the quality of the Level_1b product. In general the data shows no datation errors and in most cases good quality, however in some specific areas the re-tracked elevation shows a lack of quality. Similar results were obtained and highlighted in former reports (e.g. Helm et. al, 2006; Stenseng et al. 2007) and therefore are not shown here again, since the implemented OCOG retracker has not changed. The OCOG was developed to give a quick and rough estimate of surface elevation and not to be as precise as possible. Therefore it is up to the user of the data to apply different re-tracker algorithms instead of the OCOG.

5.4.2 Runway over flights and comparison with ALS-DEM

Runway overflights were performed in CFS Alert (29th March and 2nd April) in Lonyearbyen (27th April) at Station Nord (29th April) and in Kangerlussuaq (3rd May). Figure 13 shows the laser scanner elevation model of the Alert runway including the ASIRAS profile (black line). Gaps in the line show areas were the roll angles was larger then 1.5°. This data was excluded from the analysis. In figure 14 the comparison of the Alert overpass with the ALS-DEM is shown. The black line in the upper panel shows the ALS elevation, whereas the dark gray line shows the ASIRAS elevation. The light gray line shows the roll angle. A difference of 3.67 +/- 0.03 between both elevations is determined with the OCOG retracker. The lower left panel shows the variation of the difference around the median value. Statistics of this variation is shown in the histogram. To mention, this offset was not considered in the final ASIRAS level_1b processing, because of it is dependent on the choice of retracker. Table 7 lists all runway overflights and the calibration results.

Table 7: Runway calibration

Profile	Start time	Stop time	Time shift (s)	Offset (m)	Stddev (m)	ALS qual.	ASIRAS qual.
A120329_04	60873	60892	0.0	3.70	0.04	Good	Good/offtrack
A120402_04	62429	62453	0.0	3.67	0.03	Good	Good
A120427_04	68530	68543	0.0	3.62	0.2	outliers	Roll/offtrack
A120427_05	68980	68993	0.0	3.67	0.46	outliers	Roll/offtrack
A120429_03	49573	49601	0.0	3.66	0.04	Good	roll
A120429_03	50010	50033	0.0	3.64	0.06	Good	Good/offtrack
A120505_03	57447	57498	0.0	3.72	0.06	Good	Good

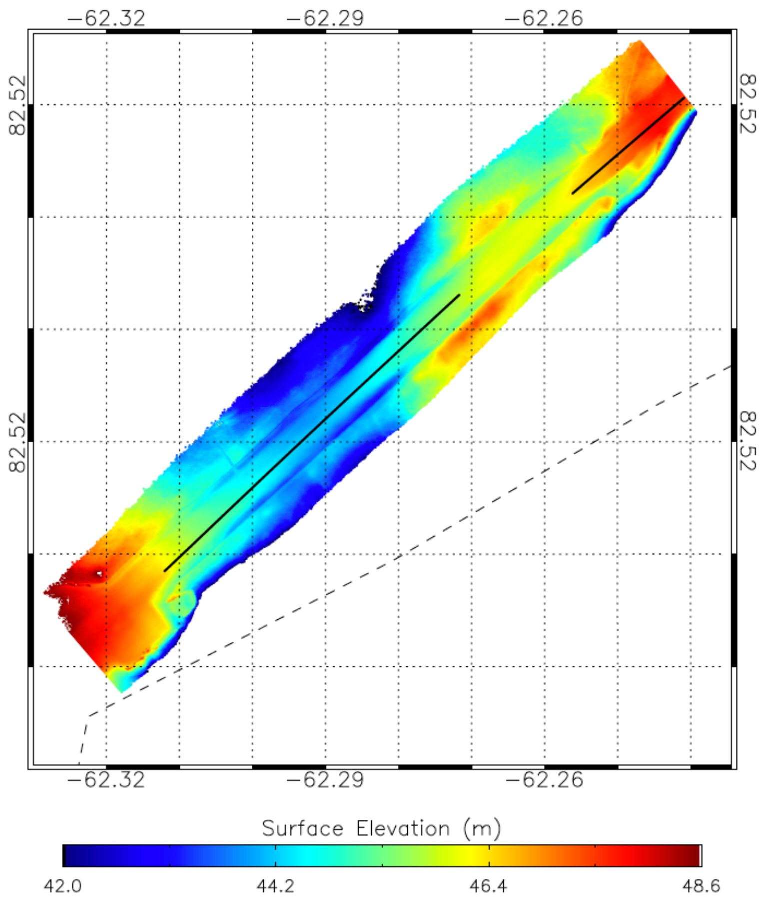


Figure 13: Laser scanner elevation model of runway in CFS Alert

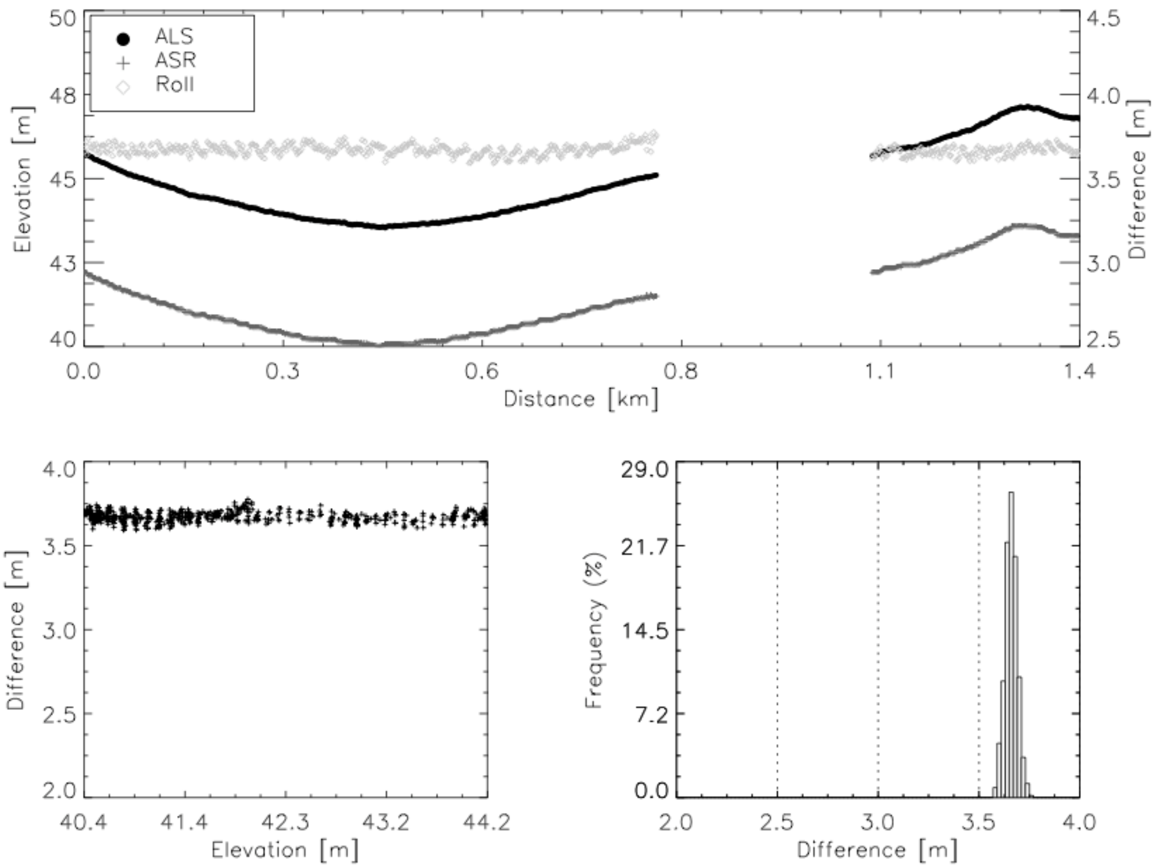


Figure 14: Comparison of ALS and ASIRAS elevations over runway. Top shows ALS elevation in black dots, ASIRAS elevation in dark grey dots and the light gray diamonds shows Difference between ALS and ASIRAS elevation. Bottom shows variation of the difference and ist statistics.

5.4.3 Corner reflector over flights

Throughout the campaign there have been overflights of the corner reflectors put out at the test sites. The positions of all the corner reflectors can be found in Table 8. All CR-passes were analyzed and close passes are listed in Table 9. It can be seen that only the 12DEV2 corner reflector can be clearly identified in the ASIRAS data, although most of the passes were very close. An example of Level_1b processed ASIRAS data of the CR pass over the Devon validation site is shown in Figure 15. The 12DEV2 corner reflector was hit around 0.13 km (58620.81s) and appears after processing as point target roughly 1 m above the surface. A weaker second point target around 0.15 km show the 12DEV1 corner reflector. A subsurface layer can also be identified roughly 1m beneath the surface in this profile section.

Table 8: Positions of corner reflectors installed in CryoVEx 2012

CR	Latitude	Longitude	Ground elevation (m)	Height (m)
12DEV1	75.338057	-82.677513	1796.18	1.53
12DEV2	75.338249	-82.678066	1796.47	1.66
12DEV3	75.338482	-82.678682	1796.61	1.42
12ALERT	82.52635	-62.20639	40.0	1.85
12AUST1	79.733617	22.417940	754.69	1.35
12AUST2	79.784674	23.155669	686.40	1.58
12AUST3	79.814743	23.709956	817.97	1.48
12AUST4	79.830621	23.976139	670.89	1.56
12AUST5	79.942600	24.243390	422.68	1.40

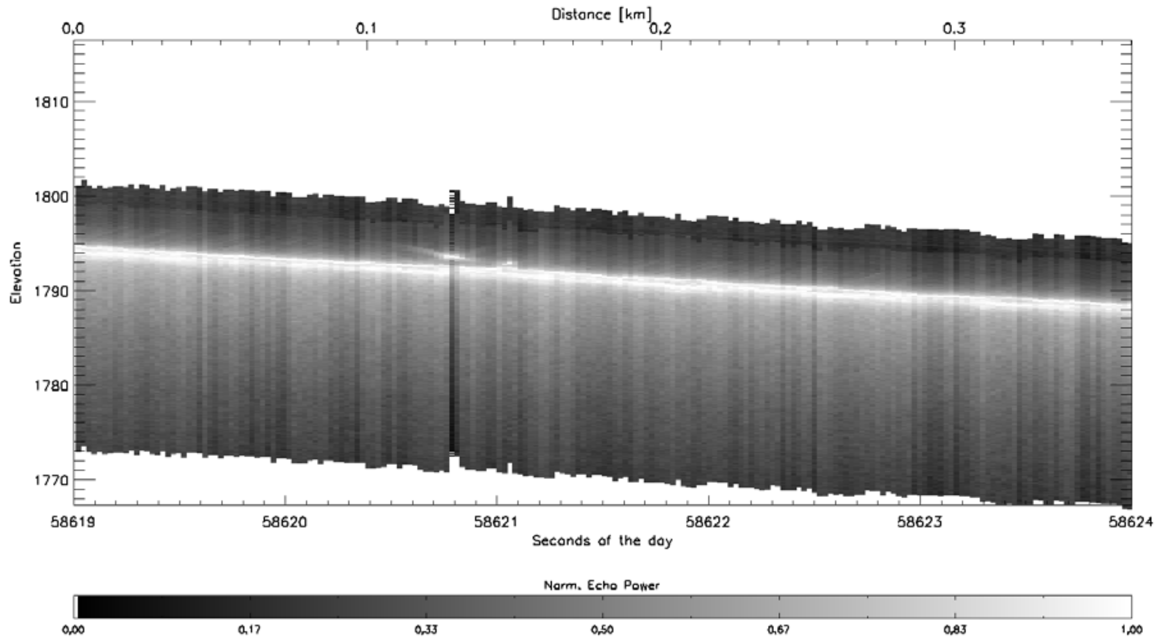


Figure 15: Successful CR pass over the validation site on the Devon Icecap after ASIRAS processing. The CR is seen as point target roughly 1 m above the surface.

Table 9: CR passes.

CR	Profile	Closest approach	Time	In the data?
12DEV1	A120503_02	13.22	58621.09	Very weak
12DEV2	A120503_02	5.42	58620.81	Yes
12DEV3	A120503_02	26.08	58620.52	No
12DEV1	A120503_03	27.75	60790.43	No
12DEV2	A120503_03	6.67	60790.19	Yes
12DEV3	A120503_03	18.85	60789.95	No
12ALERT	A120402_04	2.59	62206.40	No
12ALERT	A120403_04	1.39	66625.32	Very weak
12AUST1	A120428_03	26.36	38192.66	No
12AUST2	A120428_03	8.91	38420.23	No
12AUST3	A120428_03	2.13	38586.06	Very weak
12AUST4	A120428_03	6.59	38665.23	No
12AUST2	A120428_01	1.52	37106.46	Weak
12AUST3	A120428_07	7.89	45171.05	No
12AUST4	A120428_05	0.28	41834.80	No
12AUST4	A120428_04	3.40	40531.62	No
12AUST5	A120428_06	5.51	44174.77	No

5.5 Camera

To complement the analysis of ALS and ASIRAS data over sea ice high resolution images are collected along the flights. Two cameras were used systematically and supported by a third camera for occasional photos and video.

The slant-looking images are obtained using a camera of type Canon 60D. The camera was mounted in the rear window in the cabin using a Fat Gecko camera mount, see Figure 16. A nadir-looking camera of type Canon G10 was mounted together with heater elements in a box in the hole in the rear baggage compartment next to the laser scanner (Figure 16). Both cameras were remote controlled and time tagged using the internal camera clock. By combining the time tag of the images with GPS data the images can be geo-located along the flight lines. An overview of the properties of the cameras is given in Table 10 and examples are shown in Figure 17-18. The user is provided with an ASCII-file of the time-tagged and geo-located images according to file format listed in Appendix 7.6, together with the images packed in zipped files each including one hour of images, see Appendix 11.

Table 10: Overview of camera types and settings.

Camera type	**View**	**Interval (sec)**	**Resolution (pixels)**	**Image size (MB)**	**Software program**
Canon 60D	Slant-looking	4	3456x2304	~3	DSLR Remote Pro 232
Canon G10	Nadir-looking	4	4416x3312	~4	PSRemote 222
Olympus E-PL3	Slant-looking	Occasional	varying	varying	Manual

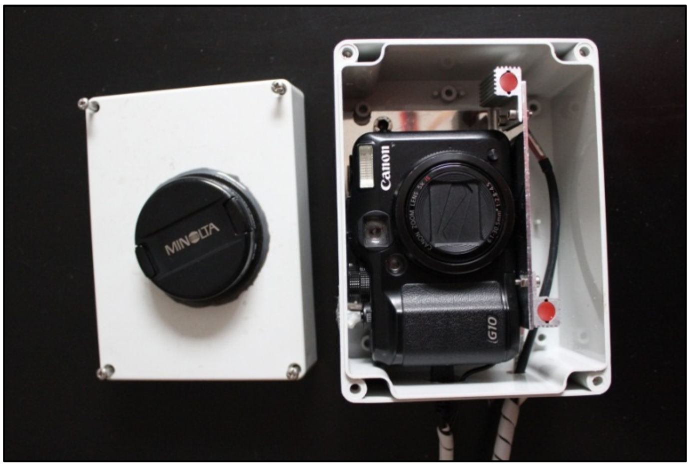
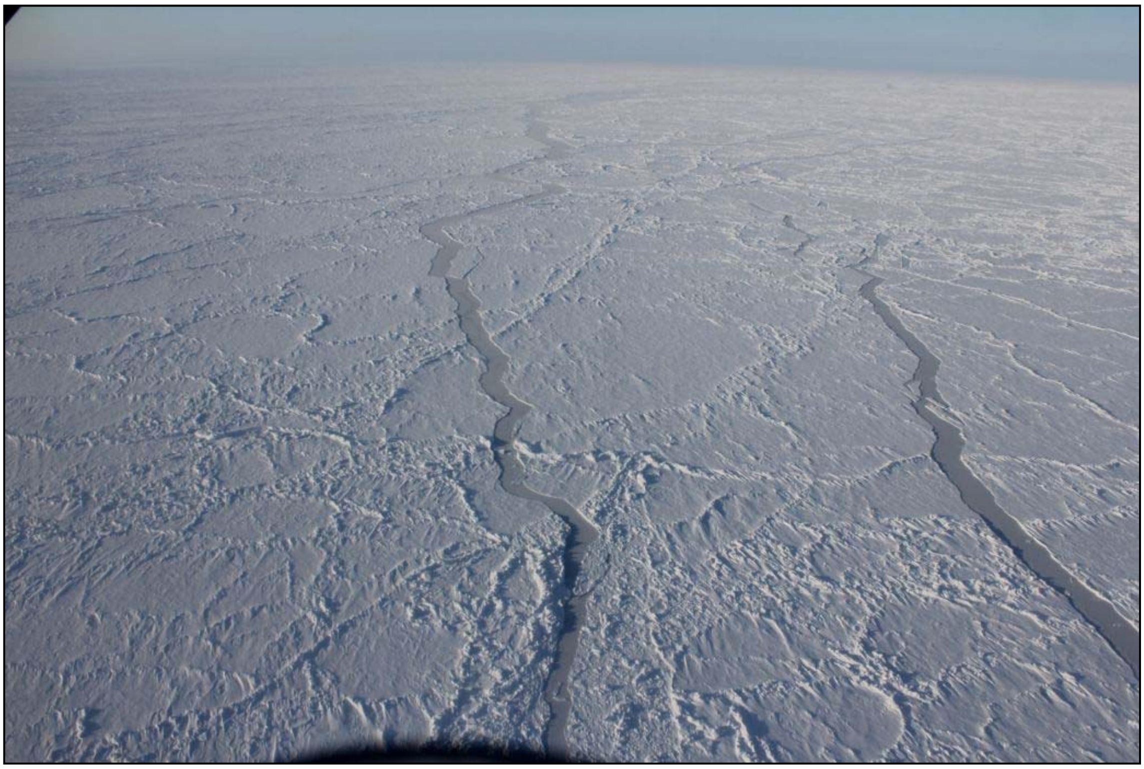


Figure 16: Camera mount (Fat Gecko) to attach to window (left) and installation of nadir-looking camera in grey box with heater elements (right).



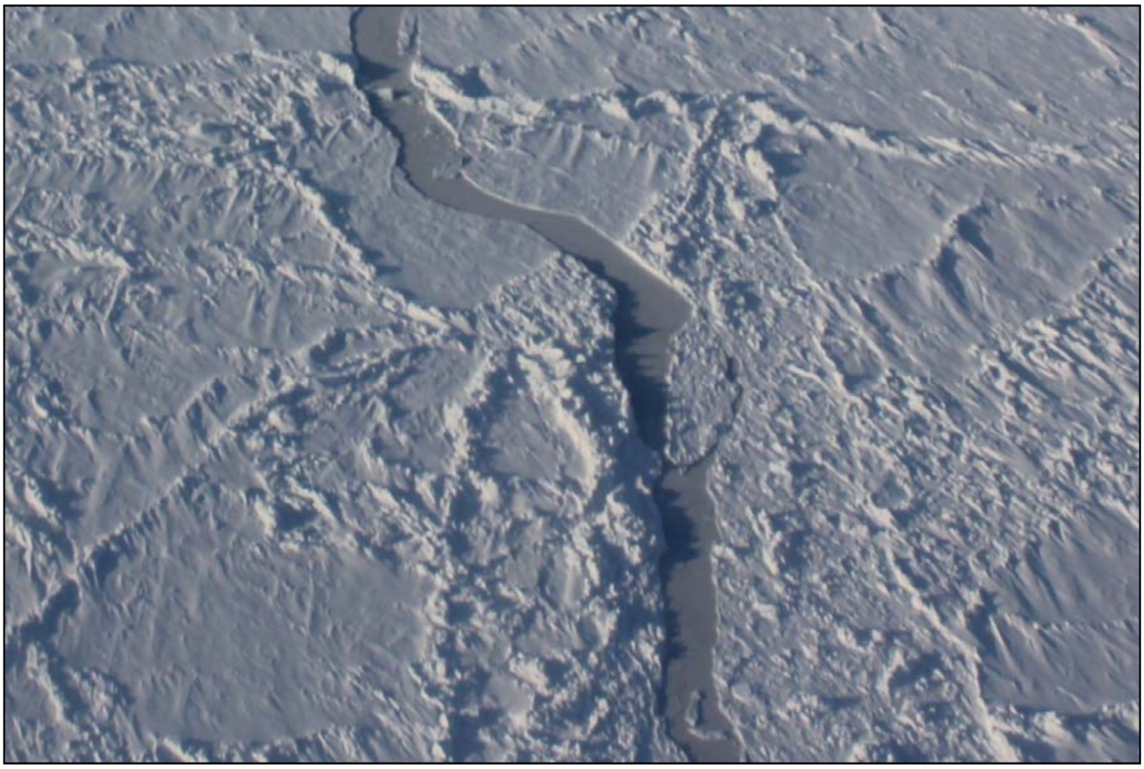


Figure 17: Example of slant-looking image taken out of rear starbord window using Canon 60D. Full resolution image (upper) and sample in full zoom (lower).

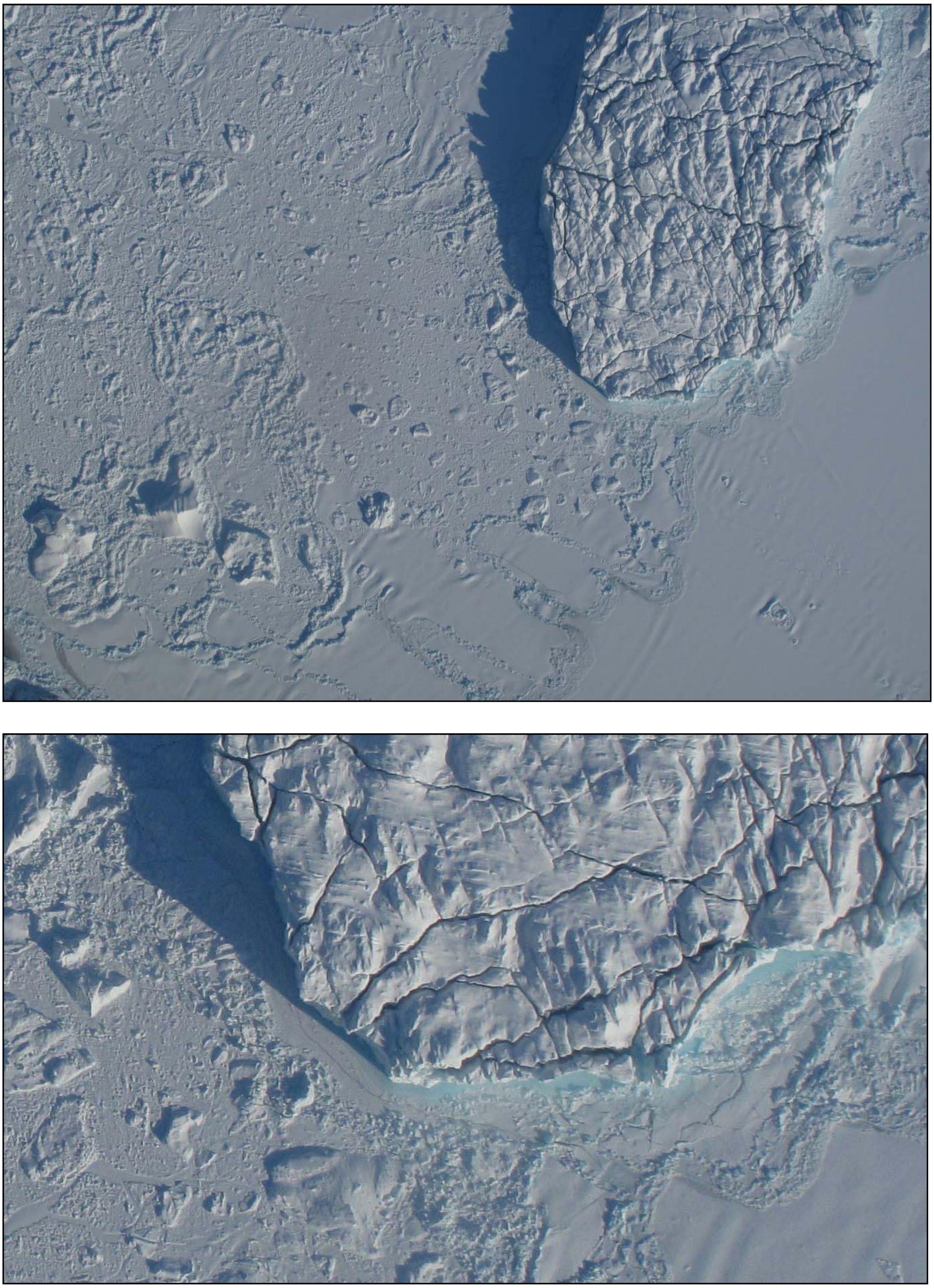


Figure 18: Example of nadir-looking image taken out of the hole in the rear bagage compartment of the aircraft using Canon G10. Full resolution image (upper) and sample in full zoom (lower).

6 Calibration and Validation sites

During the CryoVEx 2012 campaign a total of 16 CryoSat-2 ground tracks were flown covering distances from 81-523 km. All airborne data acquisitions along CryoSat-2 ground tracks are listed in Table 11, together with information of CryoSat-2 orbit numbers, passage time, mode and data acquisition.

6.1 Sea ice

In total, eight CryoSat-2 underflights were performed over sea ice, as outlined in Figure 19. Data was acquired in the Arctic Ocean north of Alert, north of Station Nord and north of Svalbard. These three areas represent different sea ice types and settings, with very rough ice north of Greenland and thinner ice north of Svalbard. The track marked by red is data acquired in the "Wingham box" (confined by 80-85^{o}N and 100-140^{o}W), where SIRAL is switched to SARIn mode.

For satellite underflights, timing is crucial especially over drifting sea ice. This was unfortunately difficult due to limited opening hours of the airports. To account for the ice drift between data acquisition of flights and CryoSat-2 passages, most of the tracks were measured twice. In addition, information of the drift was kindly prepared from repeated SAR images from ENVISAT and distributed to the involved field teams by R. Saldo (DTU Space).

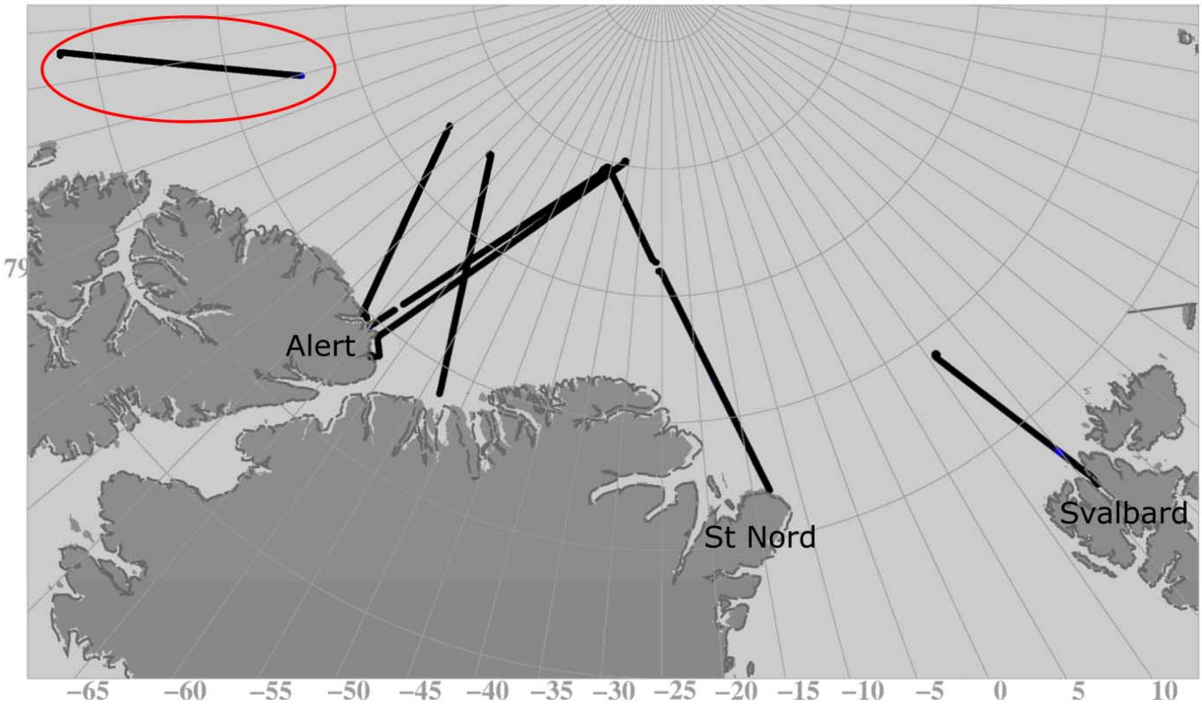


Figure 19: Flight tracks from underflights of CryoSat-2 in the Arctic Ocean.

Table 11: Overview of airborne data acquisitions along CryoSat-2 ground tracks, together with information of CryoSat-2 orbit numbers, passage time, mode and data acquisition.

Sea ice	Land ice	Location	Airborne activity	CryoSat-2 Orbit #	CryoSat-2 passage Date and time (Time given as hh:mm UTC)	CryoSat-2 Mode	Distance Covered (km)	ASIRAS	ALS	AWI AEM	NASA IceBridge	In situ
X		Lincoln Sea	29-03-2012	10462	29-03-2012 11:34	SAR	523	X	X		X	
X	X	Nares Strait/GrIS	30-03-2012	10491	31-03-2012 11:33	SAR/SARIn	216/40	X	X			
	X	GrIS	30-03-2012	10505	01-04-2012 10:42	LRM	384	X	X			
X		Lincoln Sea	02-04-2012	10520	02-04-2012 11:29	SAR	480	X	X		X	
X		Lincoln Sea	02-04-2012	10524	02-04-2012 18:03	SAR	175					
X		Lincoln sea	03-04-2012	10540	03-04-2012 20:30	SAR	420	X	X	X		
X		Lincoln sea	04-04-2012	10555	04-04-2012 21:19	SAR	360	X	X	X		
X		Wingham Box	05-04-2012	10565	05-04-2012 13:54	SARIn	425	X	X	X		
X		Svalbard	27-04-2012	10885	27-04-2012 15:03	SAR	320	X	X			
	X	Austfonna	28-04-2012	11015	06-05-2012 14:02	SARIn	81	X	X			X
	X	Austfonna	28-04-2012	11044	08-05-2012 13:59	SARIn	81	X	X			X
	X	Austfonna	28-04-2012	11110	13-05-2012 03:14	SARIn	94	X	X			X
X		Station Nord	29-04-2012	10915	29-04-2012 16:40	SAR	422	X	X			
	X	Devon	03-05-2012	10976	03-05-2012 21:30	SARIn	100	X	X			X
	X	Devon	03-05-2012	10810	22-04-2012 11:07	SARIn	90	X	X			X
	X	GrIS	05-05-2012	11098	12-05-2012 07:26	LRM	518	X	X			

As part of the CryoVEx campaign, the Alfred Wegener Institute (AWI) Bassler aircraft (Polar-5) towing an electromagnetic sounder (AEM), was based in CFS Alert (March 28 – April 5) and NASA's Operation IceBridge P-3 aircraft equipped with multiple sensors for sea ice and snow retrievals was located in Thule AB. Thus, coincident flights along CryoSat-2 ground tracks in the Lincoln Sea were planned to supplement ASIRAS and ALS data with a variety of sea ice measurements. As the AWI AEM measures the draft of the sea ice, a comparison to the ALS and ASIRAS is very important for the freeboard to thickness conversion. The snow radar onboard NASA P-3 is valuable for snow depth information to estimate ASIRAS penetration depths.

Coincident flights with Polar-5 and DTU Space Twin Otter are straightforward as the aircrafts fly at the same survey speed of approx. 110 knots. Thus, the aircrafts are able to align on the same track at the same speed only a few minutes apart, which ensures overlapping data acquisition in areas of drifting sea ice. Such formation flights were performed for the first time during CryoVEx 2011. In 2012, formation flights were flown along CryoSat-2 ground tracks on April 3 and 4. Formation flight was not possible in the "Wingham box" on April 5, as the Twin Otter started out in CFS Alert and Polar-5 started in Eureka, however, a larger temporal separation of data is less important as the ice is almost stationary in this area. For a more detailed description of the AEM flights see Chapter 7.

The flight on March 29 and April 2 was coordinated with NASA operation IceBridge. At the interception point the Twin Otter and the P-3 were only few minutes apart, but due to the higher survey speed of the P-3, the temporal separation was larger between the aircrafts at the end point. Alignment of all three aircrafts was impossible due to problems with the AEM and a tight IceBridge operation program.

Figure 20: Mounting of the AWI AEM during take-off and landing (left) and NASA P-3 aircraft (right).

Very first results of CryoSat-2 and ALS data from April 2, can be seen Figure 21. The left plot shows CryoSat-2 crossing a lead (green cross) visible in the ALS data. The plot at the right shows both laser height measurements from the airplane (grey dots) and CryoSat-2 data (green and red crosses). The green crosses correspond to CryoSat-2 measurements of sea ice and red crosses areas of thin ice or open water. The laser measurements are in general 10–20 cm above the CryoSat-2 ice elevations. The difference is most likely due to the snow layer on top of the sea ice.

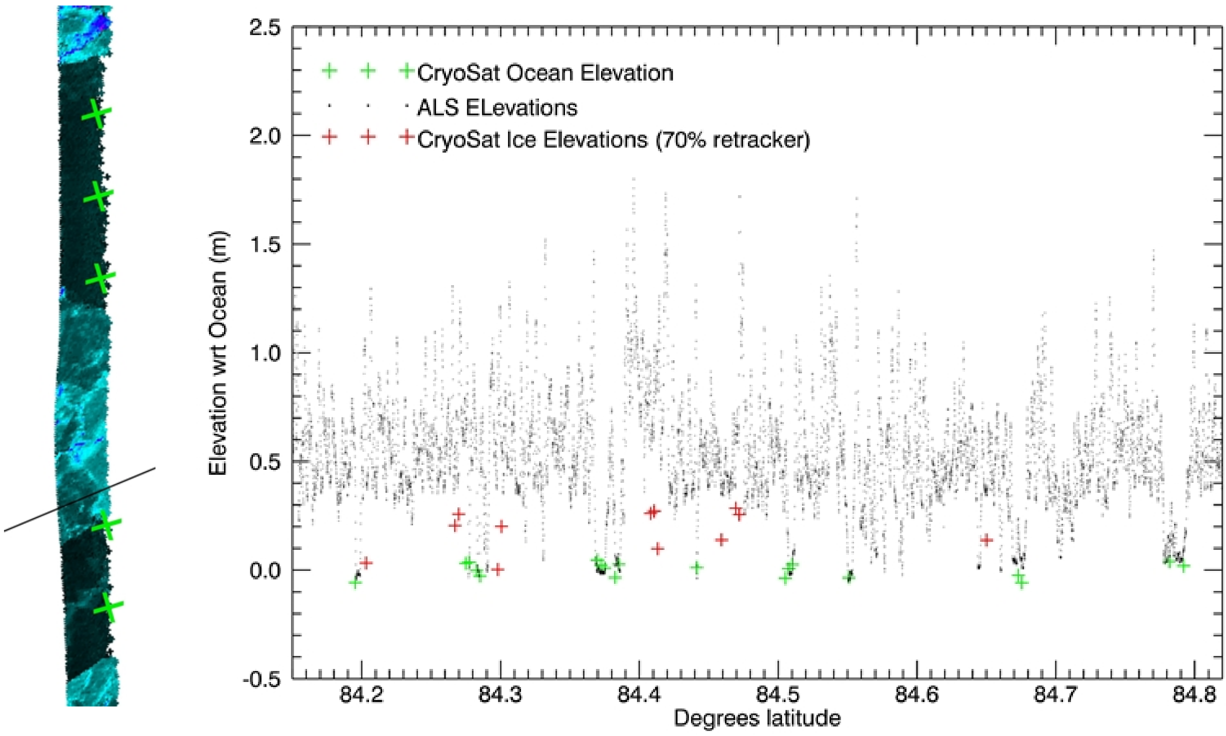
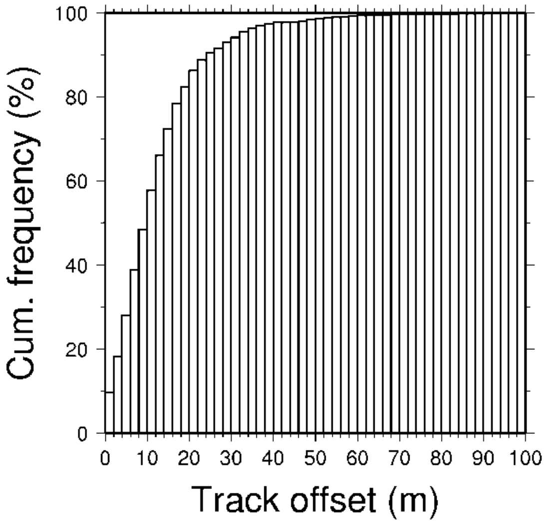


Figure 21: CryoSat-2 crossing a lead (green cross) visible in the ALS data (left), together with CryoVex campaign results from 2 April 2012 (right). Credits: M. Fornari (ESA), T. Armitage (ESA) and H. Skourup (DTU Space).

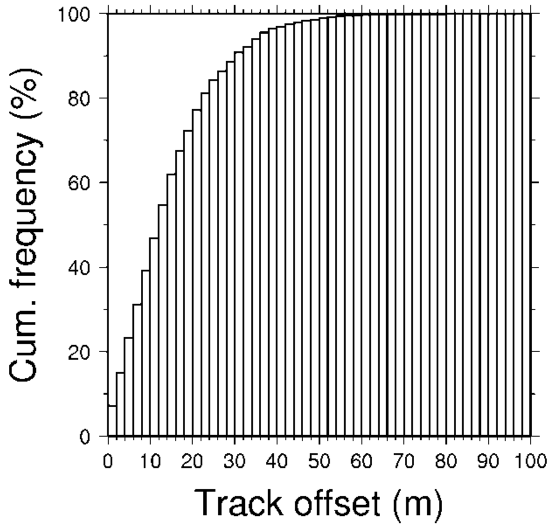
For coincident flights the aircraft navigation accuracy is important in order to track the same sea ice. The attainment of correct flight lines are secured by a DTU Space in-house developed real-time software, which both allows pilot and scientists to monitor the flight locations in real time, relative to a planned track. The track accuracy for four flights (DOY 89, 93, 118 and 120b) following CryoSat ground tracks, are given in Figure 22 (a-d).

The tracks flown on DOY 089 and 093 are flown using the autopilot with minor adjustments from the pilot. The flight on DOY 118 was flown in excellent conditions and with constant manual adjustment of the pilot to keep the aircraft on track. As seen in Figure 22, the track accuracy is reduced to the half by constant manual corrections of the pilot. This is however, very demanding for the pilot and it should only be used when a high track accuracy is needed. DOY 120b where flown in very windy conditions, but still kept within a reasonable accuracy and comparable to the track accuracy obtained during CryoVEx 2011, Skourup et al. (2012).

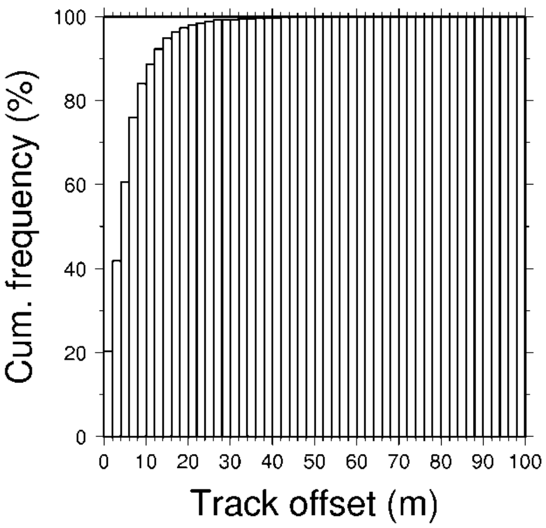
For shorter flights it is routinely possible to obtain a nominal track accuracy at the 10 m level with the navigation equipment, thus giving the necessary navigation accuracy for hitting ASIRAS corner reflectors on the ground, see Section 6.2.



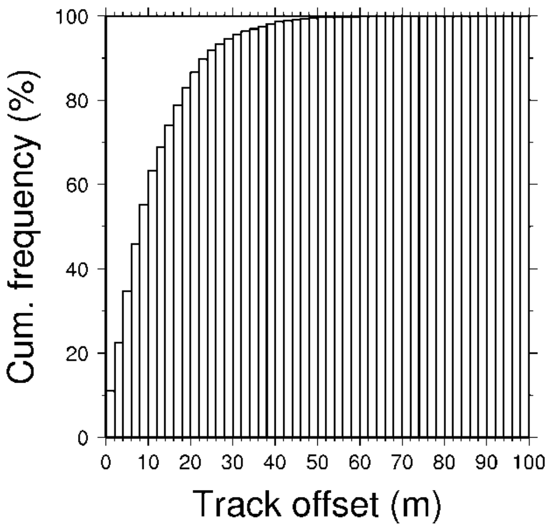
a) 29-03-2012, DOY 089 CryoSat track 10462
95% at 32m



b) 02-04-2012, DOY 093 CryoSat track 10520
95% at 36m



c) 27-04-2012, DOY 118 CryoSat track 10885
95% at 14m



d) 29-04-2012, DOY 120b CryoSat track 10915
95% at 28m

Figure 22: Track accuarcy

6.2 Land ice

Measurements of land ice include the Greenland ice sheet (the EGIG line and CryoSat- 2 ground track 11098), Austfonna and Devon ice caps. Flights on the ice caps (Devon and Austfonna) were coordinated with scientists taking measurements of snow and ice properties on the ground along CryoSat-2 ground tracks and transects of special glaciological interest. Unlike previous CryoVEx campaigns no *in situ* measurements were taken along the EGIG line, but airborne measurements are still important to monitor changes in the ice sheet mass balance.

Corner reflectors (CR) were placed by the ground teams at Austfonna and Devon ice caps. The reflectors are used as a reference point to validate the penetration of the radar signal in the upper layers of the ice cap, and to check the timing of the ASIRAS radar. An overview of the position is given in Table 5. To overfly the corner reflectors demands very precise navigation as the reflector has to be within ±5 m of the aircraft ground track. This is attained by use of DTU Space in-house developed real-time software, see Section 6.1. Furthermore, the real-time display of the ASIRAS radar indicates whether the reflector is “hit” at the time of overflight.

The cooperation between the ground and airborne teams was excellent, and contact by iridium phone with the ground teams prior to flights have been invaluable to receive update on weather conditions and positions of corner reflectors. An overview of the Austfonna and Devon ice caps are given below. The location of the flights of the Greenland ice sheet is shown in Figure 1.

6.2.1 Austfonna ice cap

The Austfonna ice cap flight was flown on April 28, 2012. Due to the limited flight time six lines were prioritized; three CryoSat-2 ground tracks (11015, 11044, and 11110) and three ASIRAS validation lines repeat from previous CryoVEx campaigns (Eton-East, NW Hartog and Line 472).

The weather was fairly good with a few low clouds in the west and northwest. ASIRAS data was collected during the entire flight, and although the laser scanner does not penetrate clouds, the cover was rather thin and data was gathered over most of the flight lines. ALS data for CryoSat-2 ground track 11110 and Line 472 has not yet been processed due to complications with the scanner file, see Section 5.3.1.

At the Austfonna ice cap the ground team from University of Oslo and Norwegian Polar Institute had put up five corner reflectors (12AUST1-12AUST5) prior to the flight, for positions see Table 8. Three out of the five corner reflectors were within 3.4 m of the flight track, see Table 9. Two “hits” were confirmed in the air on the real-time radar display, however, by some unkown reasons only two very weak signals were obtained in the post-processed ASIRAS data. The reflector near the camp 12AUST1 is 26.36 m apart from the actual flight track, due to large variations of the topography in the area, which decreases the precision of the navigation.

6.2.2 Devon ice cap

The survey of Devon ice cap was scheduled to take place on May 2 from Thule AB. The ground team from the Geological Survey of Canada and the University of Alberta was already established in a camp near the summit (see photo) and the corner reflectors were in place, see Table 8. However, during startup of the aircraft engine the electrical system failed. Due to the limited operation hours of the aircraft the flight had to be postponed to May 3.

Even though the satellite image in the morning showed low clouds on Devon ice cap on May 3, the weather turned out to be perfect. All planned flight tracks were flown, including two CryoSat-2 ground tracks (10976 and 10810), two repeat tracks from previous CryoVEx campaigns (line 623 and 450) and additional the Belcher line. The CryoSat-2 ground track 10976 was actually overflown by CryoSat-2 on the same day as the airborne survey was flown. At summit three corner reflectors had been raised each 15 m apart and diagonal to the flight lines. This ensures a larger probability of a successful overflight. The center corner reflector 12DEV2 was within 6.67 m of the flight track, and visible in the ASIRAS data for both overflights, see Table 9.

Figure 23: Summit camp on Devon ice cap.

7 Airborne EM induction sounding

In order to provide end-to-end ice thickness retrieval validation, and to address ratios of freeboard and ice thickness, airborne EM inductions ice thickness surveys were performed over the sea ice north of CFS Alert. The CryoVEx 2012 flights were carried out as part of Alfred Wegener Institute's Polar Airborne Measurements and Arctic Regional Climate Model Simulation Project (Pamarcmip; Herber et al., 2012). The Basler BT67 aircraft ("Polar 5"; Figure 24) passed through CFS Alert and Eureka during more extensive surveys in Longyearbyen (Svalbard), Station Nord (Greenland), and Resolute Bay (Canada). As Pamarcmip included a strong atmospheric research component, all flights were split into a low-altitude section to carry out ice thickness measurements, and into a high-altitude, return leg for higher-level atmospheric measurements.

Figure 24: Polar 5 at CFS Alert, with EM bird latched between landing gear. Twin Otter carrying ASIRAS/ALS can be seen in the background.

For CryoVEx 2012, three flights were performed coincidentally with the ASIRAS/ALS overflights (Figure 25, 26). Unfortunately there were significant technical problems with the EM bird starting at CFS Alert, such that no more coincident flights could be performed. Due to the limited availability of NASA's Operation IceBridge (OIB) P3, no EM ice thickness surveys could be performed during the joint ASIRAS/OIB flights. Table 12 summarized the three joint EM flights.

Table 12: Summary of coincident EM/ASIRAS flights.

Date (2012)	**Region**	**Comment**
April 3	north of Greenland	short due to poor visibility
April 4	north of Ellesmere Island	good quality
April 5	west of Ellesmere Island (inside InSAR "Wingham" box)	very noisy data

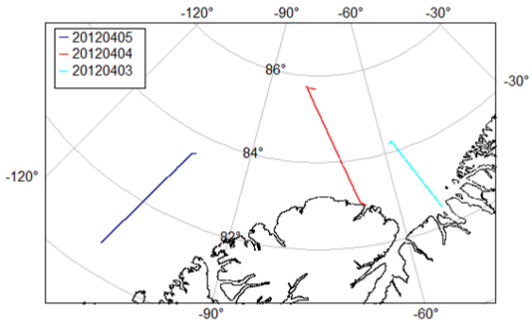


Figure 25: Map showing flight tracks of the three coincident EM/ASIRAS flights during CryoVEx 2012.

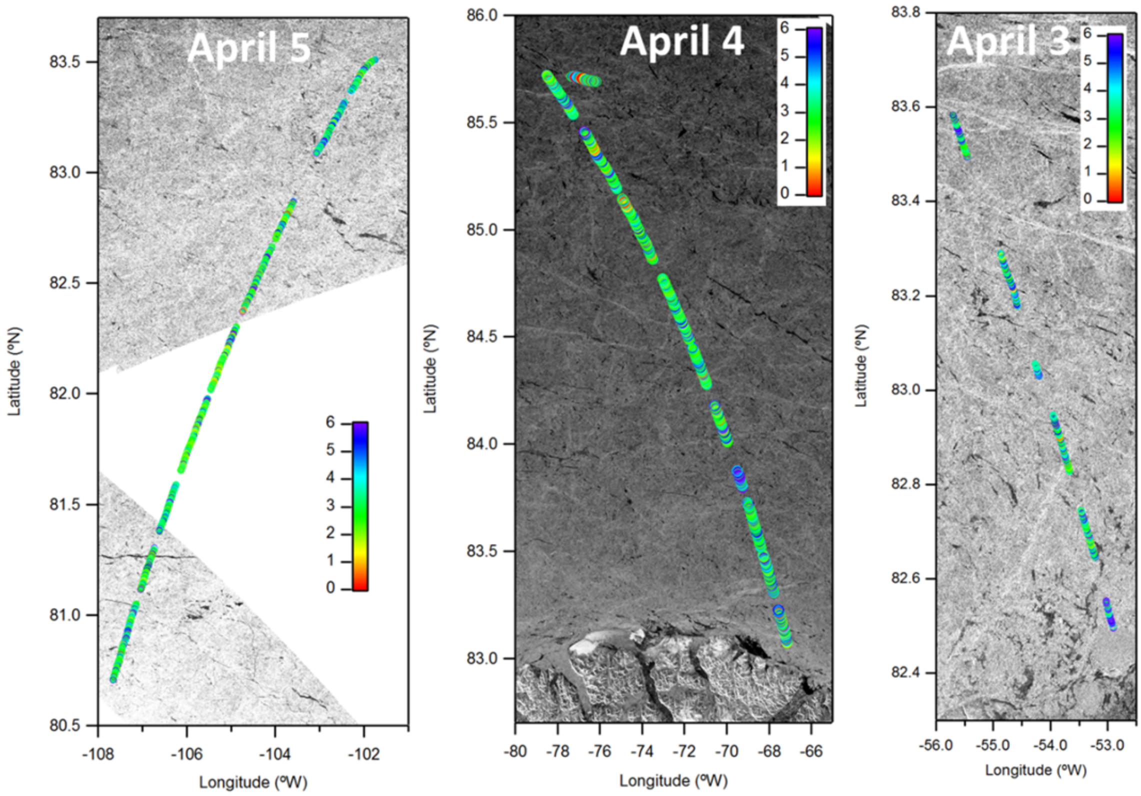


Figure 26: Envisat ASAR images of the three coincident EM/ASIRAS flight tracks, with thickness information overlaid.

Figure 27 shows the three individual thickness profiles. The data gaps in the profiles are due to sections of intermittent high altitude flight sections required for instrument calibration purposes. However, in 2012 there were also several instances where the EM system failed due to electrostatic problems related to air humidity and the specific rope used for the surveys. These data provide nevertheless important ice thickness information for direct validation with CryoSat-2, and have already been used in the study by Laxon et al. (2013).

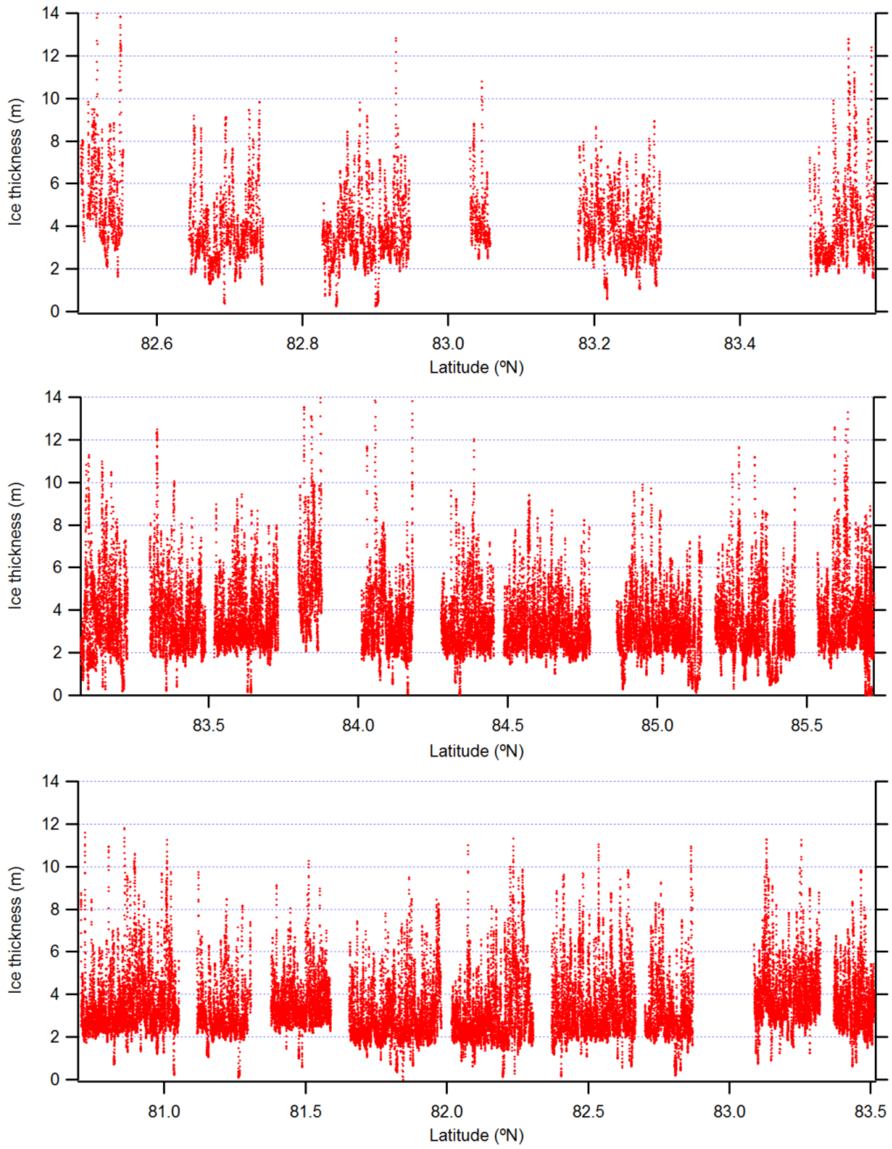


Figure 27: Ice thickness profiles obtained on April 3 (top), 4 (middle), and 5 (bottom) during the coincident EM/ASIRAS flights. Note different length scale in plots due to different length of each profile.

The thickness profiles of April 3 and 4 include significant gradients with decreasing ice thicknesses to the north which are ideal for comparisons with similar results from CryoSat-2 or OIB. Linear regression of the longest flight on April 4 resulted in the following fit:

Thickness = 26.3 - 0.27 * Lat,

yielding a 0.7 m mean thickness difference between the southern and northern ends of the profile.

Interestingly there was no significant gradient during the flight on April 5, potentially because this was in a region much further west of the flights from April 3 and 4, where ice drift is directed more parallel to the coast and parallel to the flight track.

In general the ice was quite thin when compared with surveys in the same regions in previous years, including previous CryoVEx campaigns (e.g. in 2008 and 2011). Overall, modal thicknesses ranged between only 2.25 and 2.65 m for the long flights on April 4 and 5 (Figure 28). The relatively wide range of modal thicknesses is due to the gradients mentioned above, which blur the thickness distribution when pooled together for the complete flight. The flight on April 3 was too short to result in a smooth thickness distribution. Its modal thickness is 3.25 m, representative of the thick ice near the coast of Greenland.

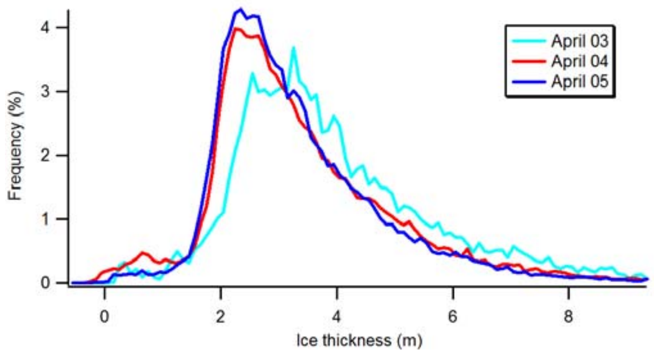


Figure 28: Ice thickness distributions obtained during all flights.

All data are available on the ESA CryoVEx ftp server. The format is described in Section 7.5.

8 Conclusion

The CryoVEx 2012 airborne campaign has been a success. In general, the weather was excellent, which allows data acquisition from all validation sites as well as most transit flights. Coincident ASIRAS, ALS and photography have been gathered along 16 CryoSat-2 ground tracks covering different sea ice conditions, parts of the Greenland ice sheet, as well as the local ice caps Devon and Austfonna. Over the sea ice most tracks were measured twice (both out- and inbound), in order to obtain a precise estimate of the ice drift. Whenever possible the tracks were timed to match the CryoSat-2 passage times, however this was hampered by limited airport opening hours, e.g. at CFS Alert.

Three coincident sea ice flights along CryoSat-2 ground tracks with Alfred Wegener Institute's aircraft Polar-5 towing an electromagnetic (AEM) sounder to measure the ice draft, were organized. Two of them took place in the Lincoln Sea out of CFS Alert, while the last flight was acquired in the "Wingham Box", where CryoSat-2 is switched to SARIn mode. These data sets together with coincident ASIRAS and ALS are very important for sea ice freeboard to thickness conversion in the CryoSat-2 validation.

Two CryoSat-2 underflights near coincident with NASA's Operation IceBridge aircraft P-3, equipped with multiple sensors for sea ice and snow retrievals, were performed in the Lincoln Sea. Unfortunaly, it was not possible to align all three aircrafts, due to technical issues with the AEM and a limited time schedule.

Flights on the ice caps (Devon and Austfonna) were coordinated with scientists taking measurements of snow and ice properties on the ground along CryoSat-2 ground tracks and transects of special glaciological interest. In addition the ground team erected several corner reflectors along the validation lines. The reflectors are used as a reference point to validate the penetration of the radar signal in the upper layers of the ice cap, and to check the timing of the ASIRAS radar. Unlike previous CryoVEx campaigns no *in situ* measurements were taken along the EGIG line, but airborne measurements were acquired, as they are still important to monitor changes in the ice sheet mass balance.

The ASIRAS and ALS instruments worked without any major problems. Based on CR analysis and comparison to coincident ALS runway overflights it is concluded that ASIRAS level_1B data processed with the ASIRAS processor version ASIRAS_04_03 shows no datation errors and an overall good quality. The ALS data is likewise of high quality with standard deviation of less than 8 cm at existing cross-over points.

9 Reference

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1 APPENDIX Operator logs

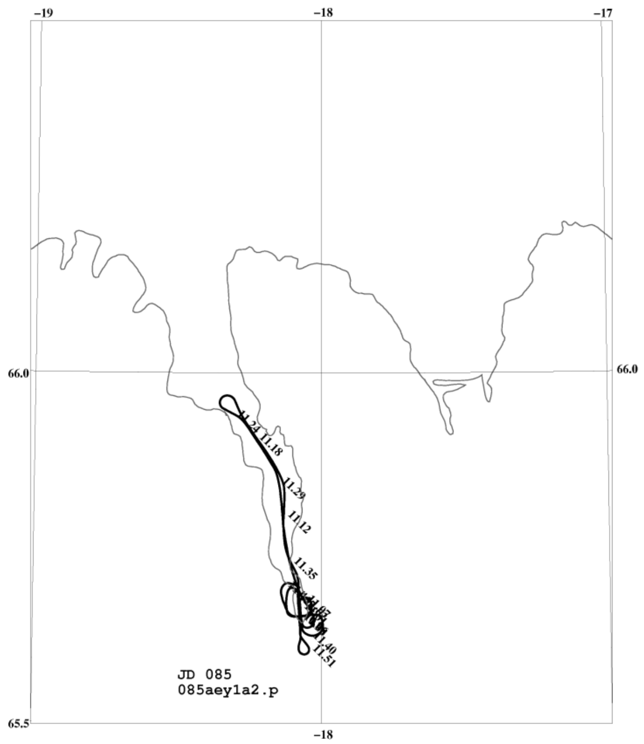
DOY 85, 25-03-2012 Test flight local AEY

1101	Take off AEY
110500	Start scanner file
1110	Climb to 450m
1122	Runway overflight scanner only, 300m
1125	B1 E-W
1129	B2 N-S
1132	B3 S-N
1135	B4 W-E
1138	On ground AEY

ASIRAS LOG

Operator Harald Lentz

ASIRAS OK

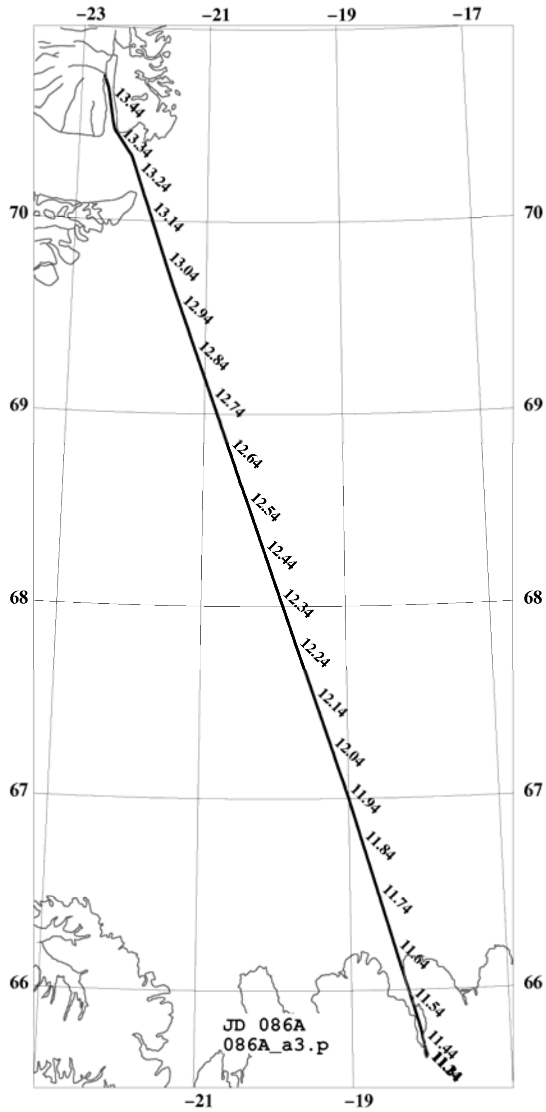


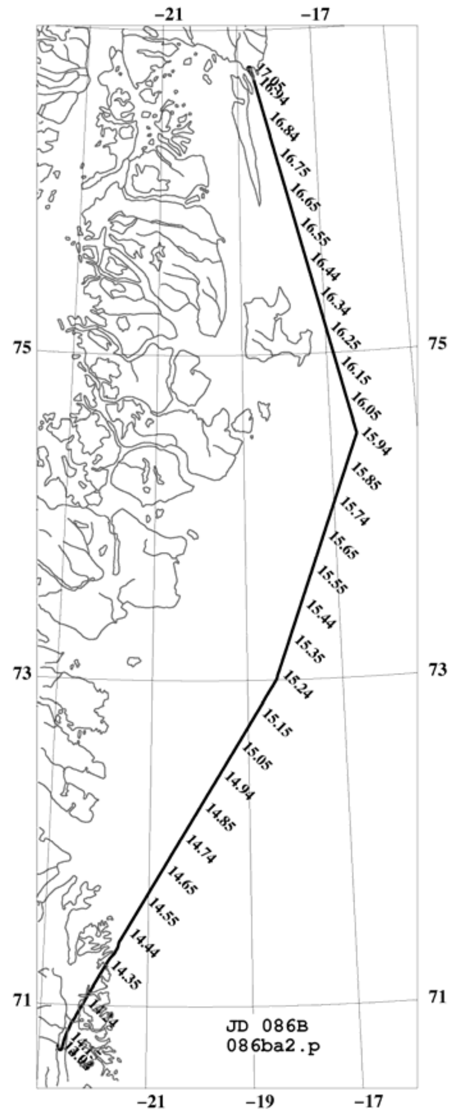
DOY 86, 26-03-2012 AEY-CNP, CNP-K1-K2-DMH

1122	Take off AEY
	No survey due to clouds
131500	New scanner file, Scoresbysund
1326	Stop scanner
1330	On ground CNP
1402	Taxi
1404	Take off, CNP
142400	New scanner file
1450	No scanner data due to low clouds
1452	Stop scanner
1513	WP K1
151630	New scanner file
1519	Start log file EGI :-/
1556	WP K1
160800	New scanner file
1635	Many icebergs, pics port Canon
1657	Stop scanner
1701	On ground DMH

ASIRAS LOG

Test of ASIRAS – OK



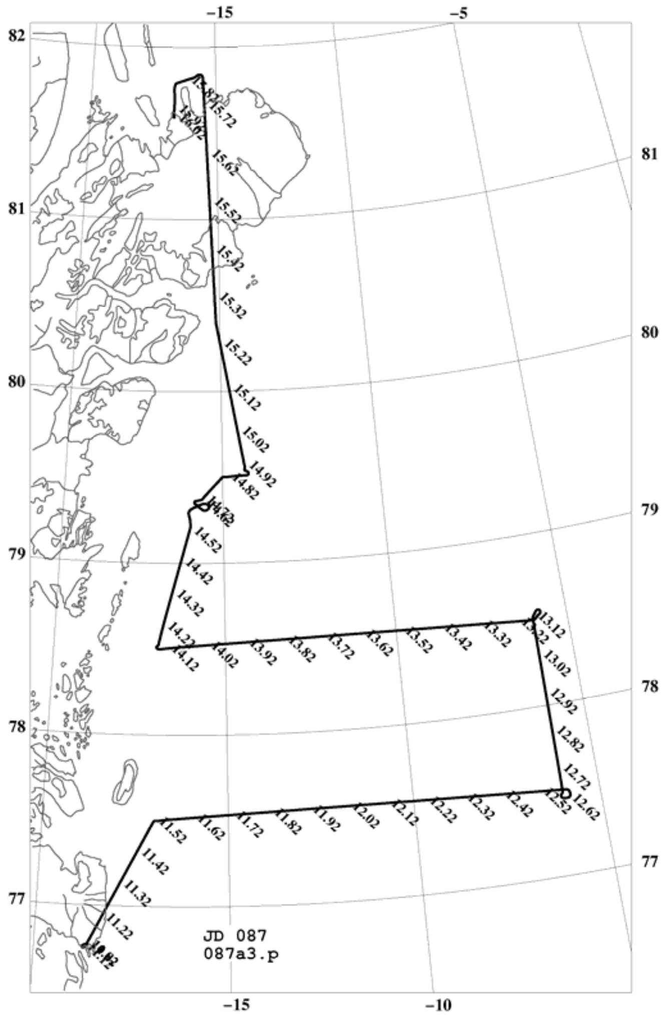


DOY 87, 27-03-2012DMH-K17-K18-K19-K20-TOB1-TOB2-TOB3-TOB4-K21-STN

1105	Take off DMH
111900	New scanner file
1234	K18
123600	New scanner file
1307	K19
130830	New scanner file
1352	Thin layer of low clouds
1408	K20
140900	New scanner file
1436	Tobias Island, TOB1
1440	Tobias Island, TOB3
1448	K21
1452	Break survey line due to weather and strong headwind
1557	On ground STN

ASIRAS LOG

1126	ASIRAS start up
	Internal calibration
	LAM mode
	Start record A120327_00.log
1236	Start record A120327_01.log
1406	Start record A120327_02.log
~1500	Stop ASIRAS

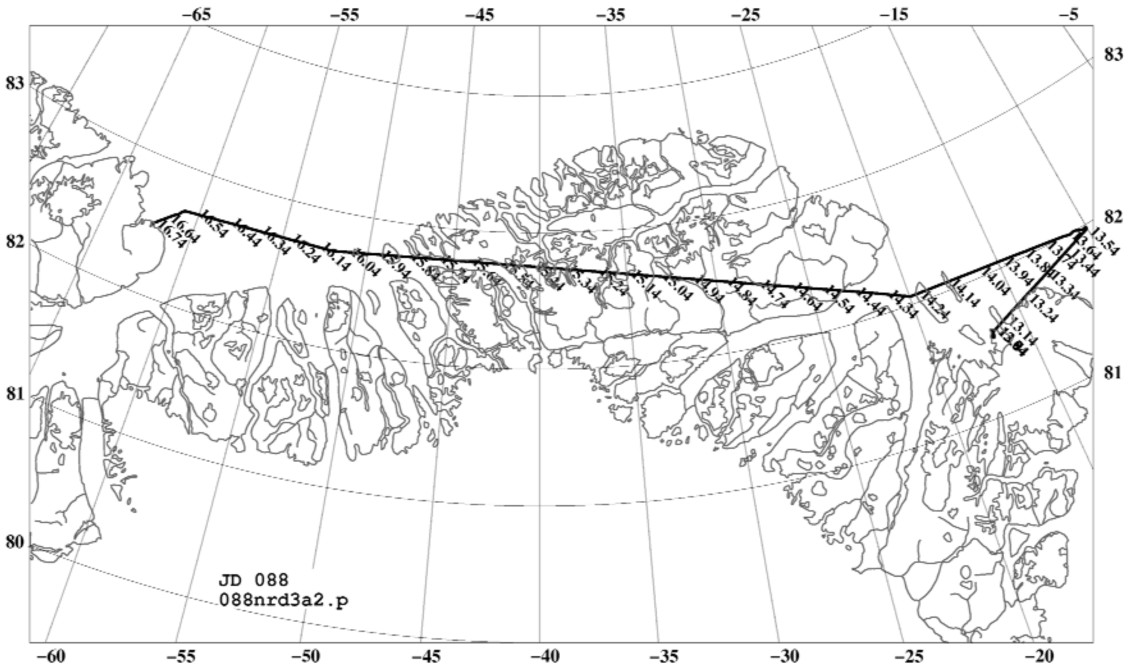


DOY 88, 28-03-2012 STN-F1-F2-YLT

1302	Take off STN, 1500 ft
130800	New scanner file
	Cannot see any signal from laser scanner
	No error messages
	Fog/icing on the scanner glass
1644	On ground YLT

ASIRAS LOG

1310	Internal calibration
1313	Start record A120328_00.log
	No ALS data
1333	Stop record



DOY 89, 29-03-2012 YLT-CRYOSAT-2 10462-CAL-YLT

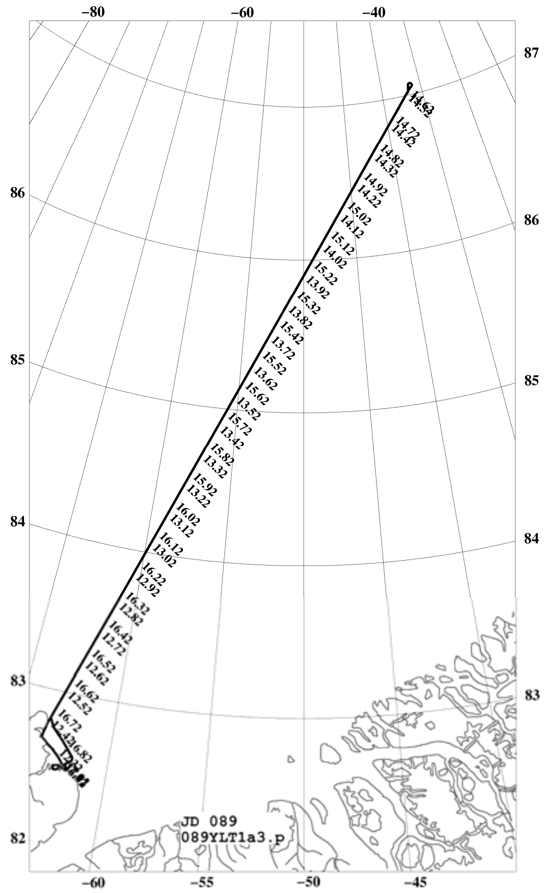
Coincident with NASA IceBridge P-3

121030	New scanner file
1213	Taxi
1215	Take off YLT
	Scanner froze direct after take off
1252	WP NC
130400	New scanner file
	Scanner set to last pulse TS1
1306	WP ND
1319	WP NE
1332	WP NF
1344	WP NG
1357	WP NH
140730	New scanner file after unplug scanner
1410	WP NI
1432	WP NJ end of track
1438	Backtrack CryoSat-2 track at 1500ft
1500	WP NI
1512	WP NH
151400	New scanner file
1526	WP NG
1538	WP NF
1551	WP NE
1604	WP ND
1616	WP NC
161800	New scanner file
1643	WP NA
1654	Runway overflight 1000ft
1658	2nd overflight Spinaker building
1701	On ground YLT

ASIRAS LOG

PRF 3000

1226	Start record A120329_00.log
1330	Start record A120329_01.log
1430	Start record A120329_02.log
1545	Start record A120329_03.log
1645	Start record A120329_04.log
	Shut down system



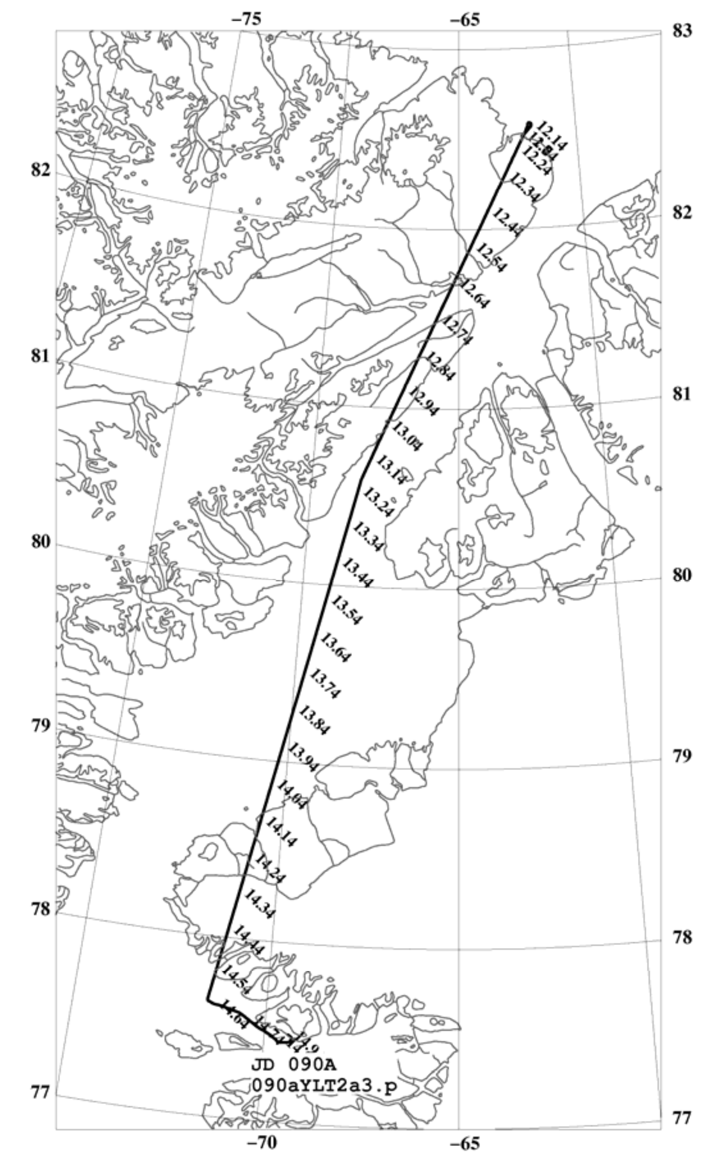
DOY 90a, 30-03-2012 YLT-CRYOSAT-2 10491-NAQ

1203	Taxi
1205	Take off YLT
120945	New scanner file
1212	Runway weak laser (no ASIRAS)
1214	Stop logging
130500	New scanner file
1311	WP C1 CryoSat-2 track 10491
1406	WP C3 End of Nares Strait
140830	New scanner file
1416	Ice cap CryoSat-2 track 10491
	Snow drift on surface
1427	End of ice cap
1431	Stop scanner
143230	New scanner file
1436	WP C4 end of CryoSat-2 track
1442	Icebergs
1452	Stop scanner
1454	On ground NAQ

ASIRAS LOG

LAM mode Standard settings

	Internal calibration
1305	Start record A120330_00.log
1405	Start record A120330_01.log
1450	Shut down



DOY 90b, 30-03-2012 NAQ-Qaanaaq fjord-CRYOSAT-2 10505-YLT

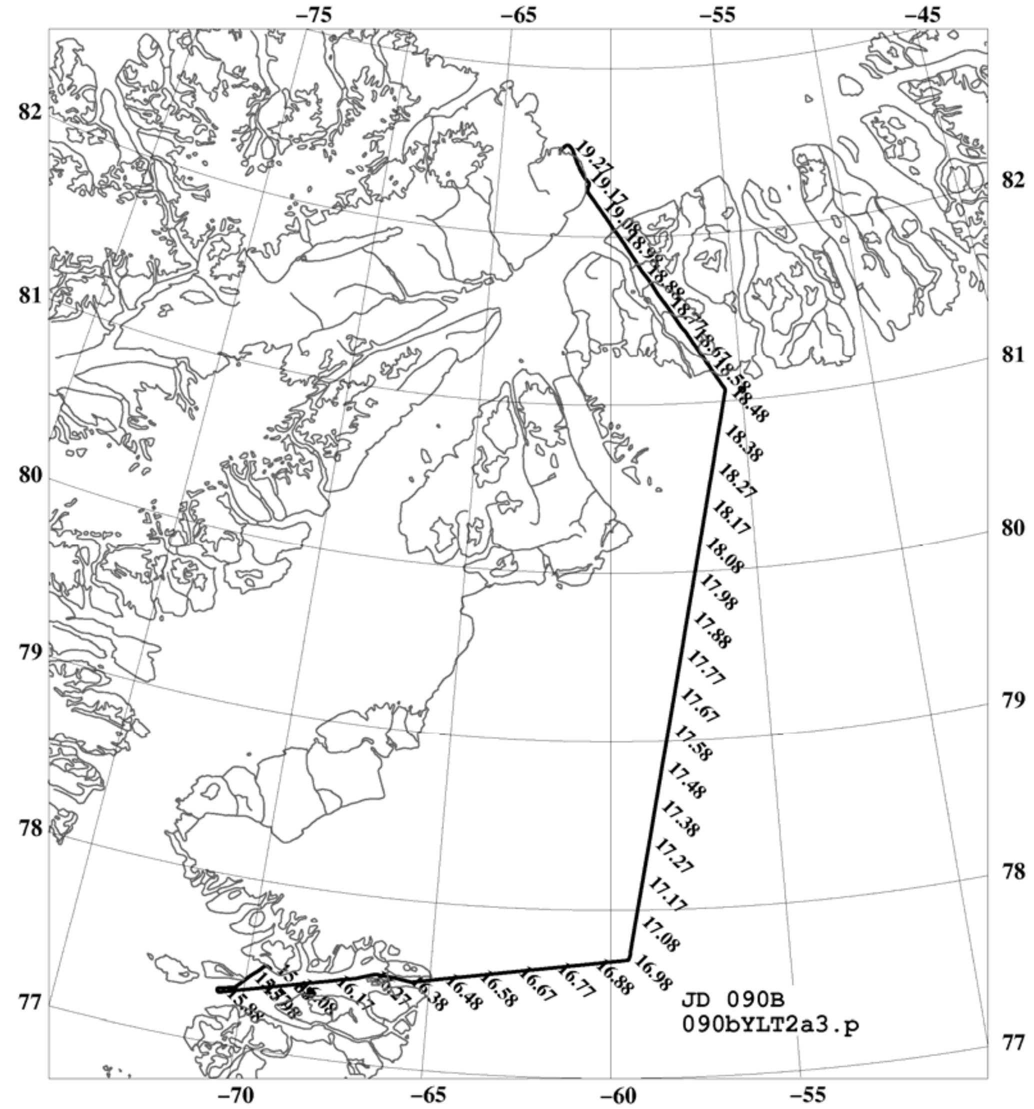
1541	Take off NAQ
154830	New scanner file
1615	End of line NAQ
1619	Glacier front
163900	New scanner file
1658	WP C5 CryoSat-2 track 10476
1724	WP C6
172800	New scanner file
1801	WP C7
1829	WP C8
1832	Ice edge, stop survey
1919	On ground YLT

ASIRAS LOG

LAM mode Standard settings

Internal calibration

1550	Start record A120330_02.log
1650	Start record A120330_03.log
1750	Start record A120330_04.log
1832	Stop record
	Shut down system

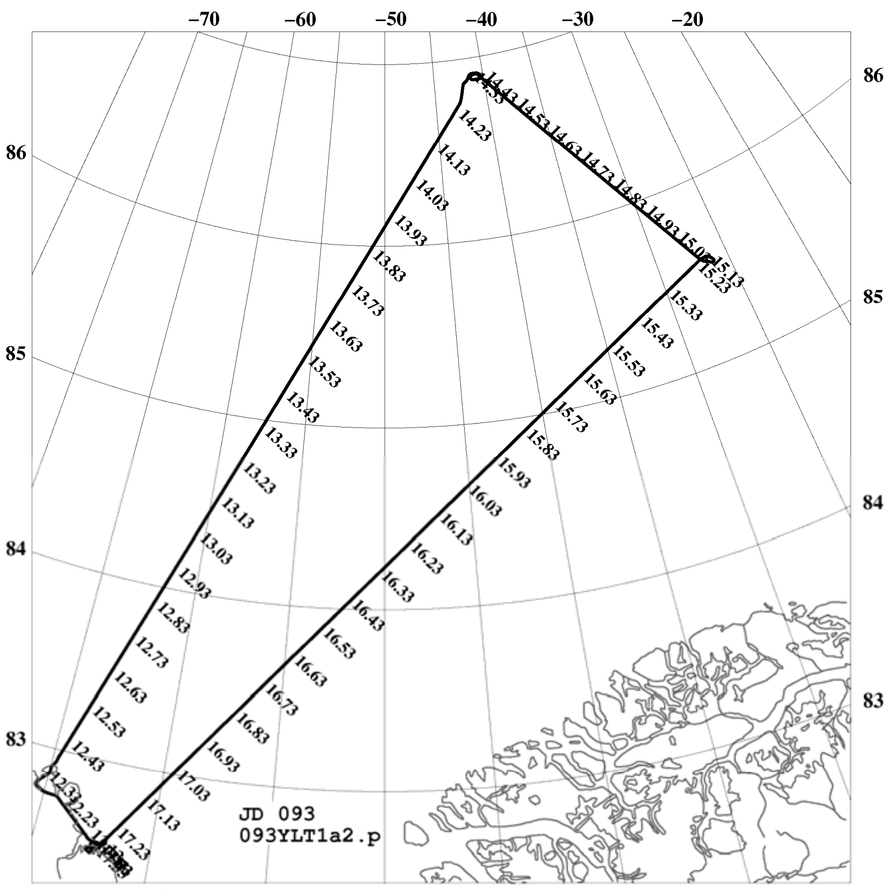


DOY 93, 02-04-2012 YLT-CRYOSAT-2 10520-CRYOSAT-2 10524-YLT

1202	Taxi
1204	Take off YLT
	Weak scanner
122000	New scanner file
1228	Sea ice on track, 1000 ft
1232	WP WB
	No scanner due to thin haze
1238	Clearing
1247	WP NC
1256	Refrozen lead
1258	WP ND
1304	Wide refrozen lead, thin white ice
1311	WP NE
131900	New scanner file
1324	WP NF
1337	WP NG
1349	WP NH
1402	WP NI
1415	WP NJ
141600	New scanner file
	Low level flight
1418	Climb to 1000 ft
1425	On line C10-C11
1446	WP C11
1506	WP C12
150800	New scanner file
160830	New scanner file
170300	New scanner file
1717	CR YLT, corner reflector
1720	Runway
1721	CR
	CR
	Stop scanner
1729	On ground YLT

ASIRAS LOG

	LAM mode Standard settings
1210	Internal calibration
1212	Start record A120402_00.log
1320	Start record A120402_01.log
1414	Start record A120402_02.log
1515	Start record A120402_03.log
1616	Start record A120402_04.log
1718	Event 1, YLR corner reflector
	Not visible on screen, 2 sec late
1721	Event 2, YLR corner reflector
1724	Event 3, YLR corner reflector
	Shut down



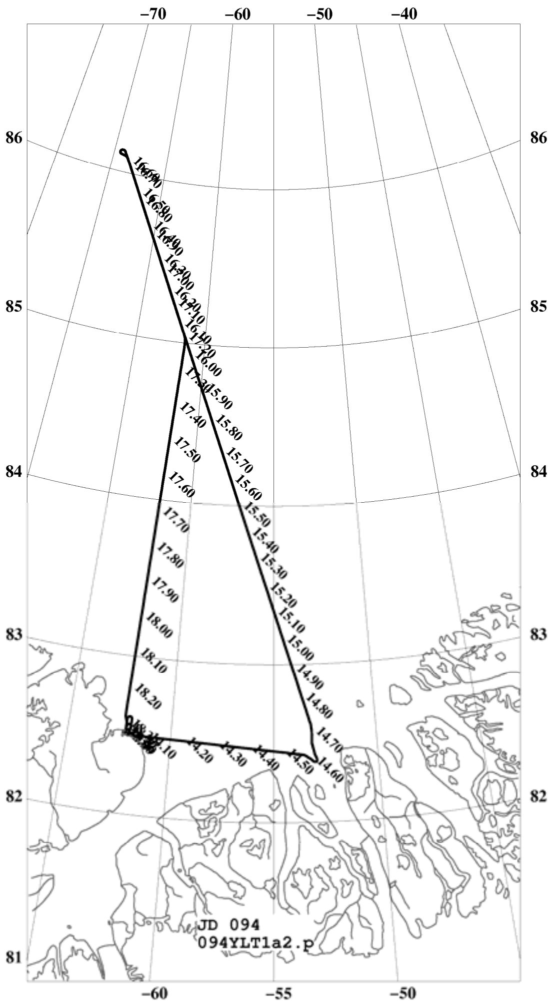
DOY 94, 03-04-2012 YLT-CRYOSAT-2 10540-CR-YLT

Formation flight with AWI Polar-5

1359	Polar-5 take off
1400	Taxi
1401	Take off YLT
	Scanner signal weak
140400	New scanner file
1414	Scanner half width (left)
1425	Scanner almost OK
1438	On line C35AEM-C34
	Lining up for C34-C33
1443	Aligned to C34-C33
150030	New scanner file
1507	Poor visibility scanner down to half the width
1520	Poor visibility
1530	WP C33
1531	Lead thin ice grey
1534	Poor visibility
1539	Polar-5 pulls out due to decreased visibility
160300	New scanner file
1602	WP C32
1604	Nice leads
1634	WP C31
	Backtrack C31-C32 for ice drift estimate
165900	New scanner file
1711	WP C32
1729	Wide lead
180300	New scanner file
1816	Deviate line to line up for CR
1819	CR
1823	CR, SDS
1830	CR, SDS
1834	On ground
1834	Stop scanner

ASIRAS LOG

	Internal calibration
1408	Start record A120403_00.log
1508	Start record A120403_01.log
1608	Start record A120403_02.log
1708	Start record A120403_03.log
1808	Start record A120403_04.log
	3x F9, reflector
1834	Shut down



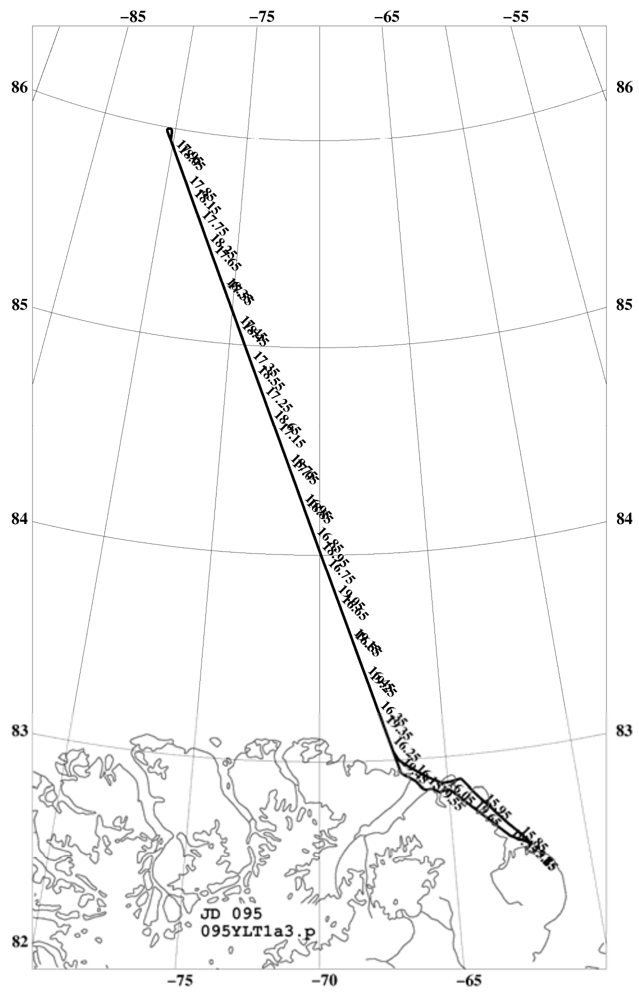
DOY 95, 04-04-2012 YLT-CRYOSAT-2 10555-YLT

Formation flight with AWI Polar-5

154430	Polar-5 take off
1545	Taxi
154633	Take off YLT
	Weak signal scanner
160600	New scanner file
1609	Scanner only half width
	On line C13-C14
1621	Full scan
1642	WP C14
171100	New scanner file
1748	Polar-5 pulls out due to poor visibility
1753	No scanner data
1757	WP C16
1758	Stop scanner
1759	break the line due to icing
	backtrack CryoSat-2 track
180400	New scanner file
1830	WP C15
1859	WP C14
185930	New scanner file
1928	WP C13, stop scanner
1950	On ground YLT

ASIRAS LOG

1553	Internal calibration
1555	Start record A120404_00.log
1705	Start record A120404_01.log
	PC1 freezes
	Hard reboot
	Restart system
1710	Start record A120404_01.log
1752	SDS, lead
1810	Start record A120404_02.log
1813	SDS, ridge
1827	SDS, frozen lead
1853	SDS, lead
1910	Start record A120404_03.log
1929	Stop
	Internal calibration



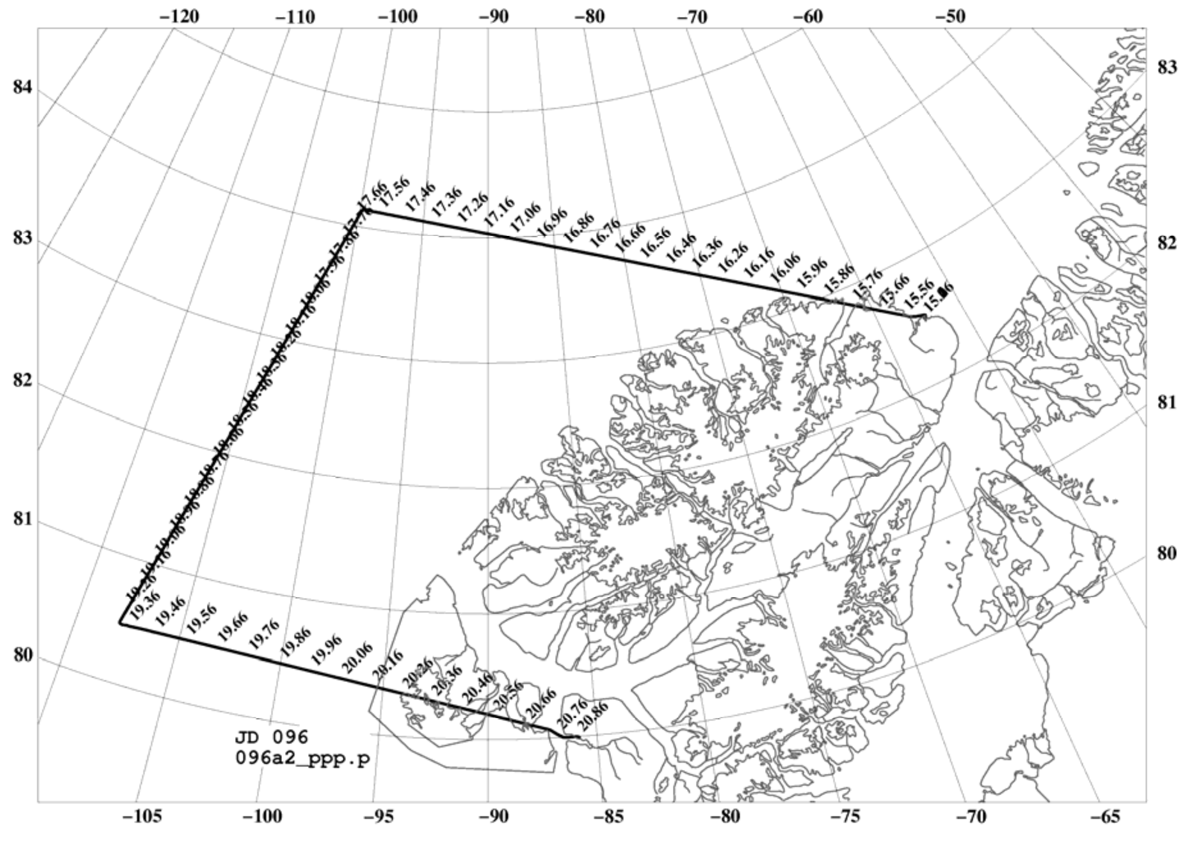
DOY 96, 05-04-2012 YLT-CRYOSAT-2 10565-YEU

Polar-5 ahead on CryoSat-2 10565 take off from YEU

1526	Taxi
1528	Take off YLT
155000	New scanner file
1626	Poor visibility no scanner
1634	Poor visibility no scanner
1641	No scanner
1642	Climb to 376m
	Stop logging
164500	New scanner file
1648	Stop logging
170000	New scanner file
1704	Stop logging
171030	New scanner file
1734	Lining up to next line
1736	Patches of low clouds
1738	On line C21-C22
180530	New scanner file
1807	WP C22
1831	WP C23
1855	WP C24
190030	New scanner file
1918	WP C25
1920	Stop scanner
2051	On ground YEU

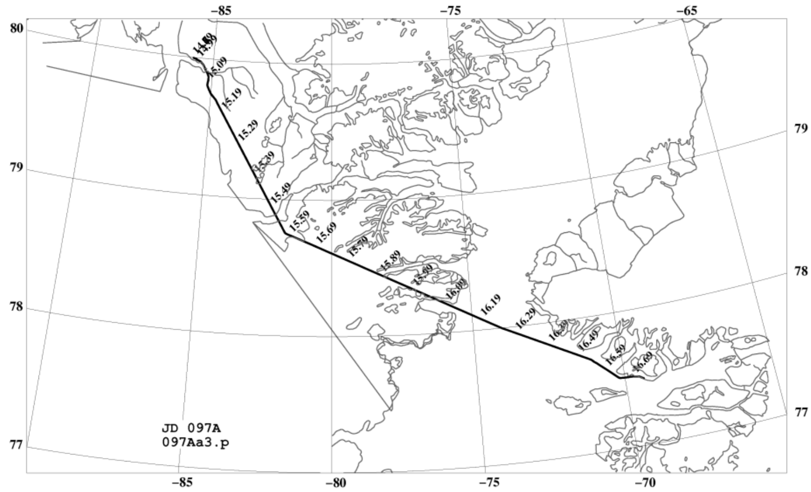
ASIRAS LOG

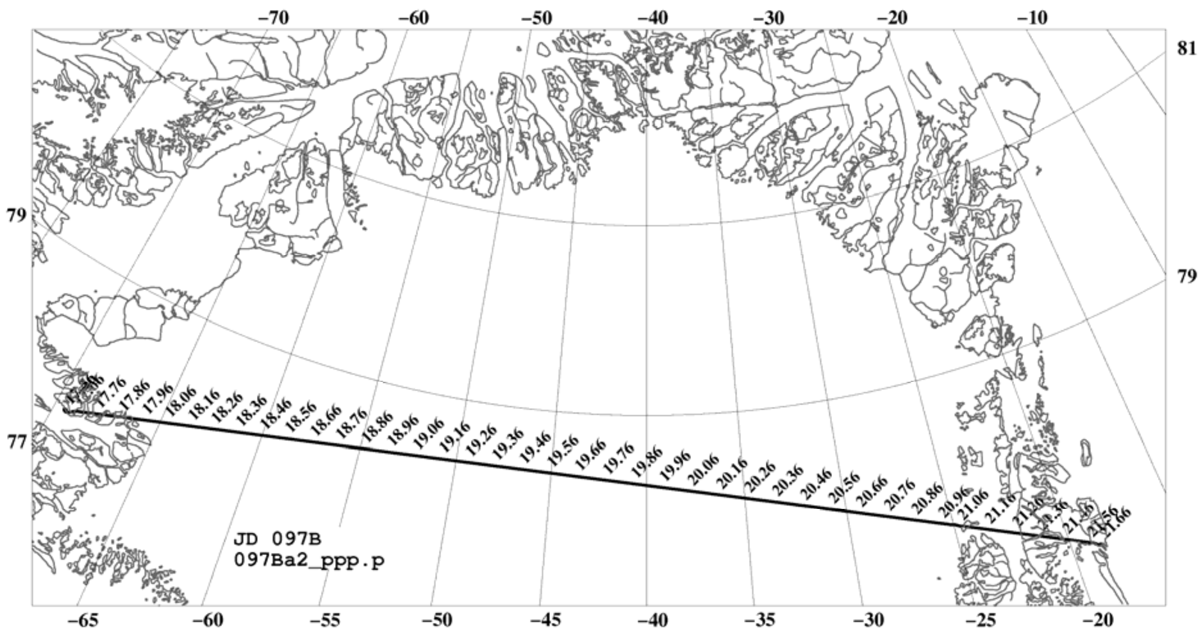
	Internal calibration
1545	Start record A120405_00.log
1645	Start record A120405_01.log
1745	Start record A120405_02.log
1845	Start record A120405_03.log
1920	Stop record, internal calibration



DOY 97, 06-04-2012 YEU-NAQ, NAQ-DMH

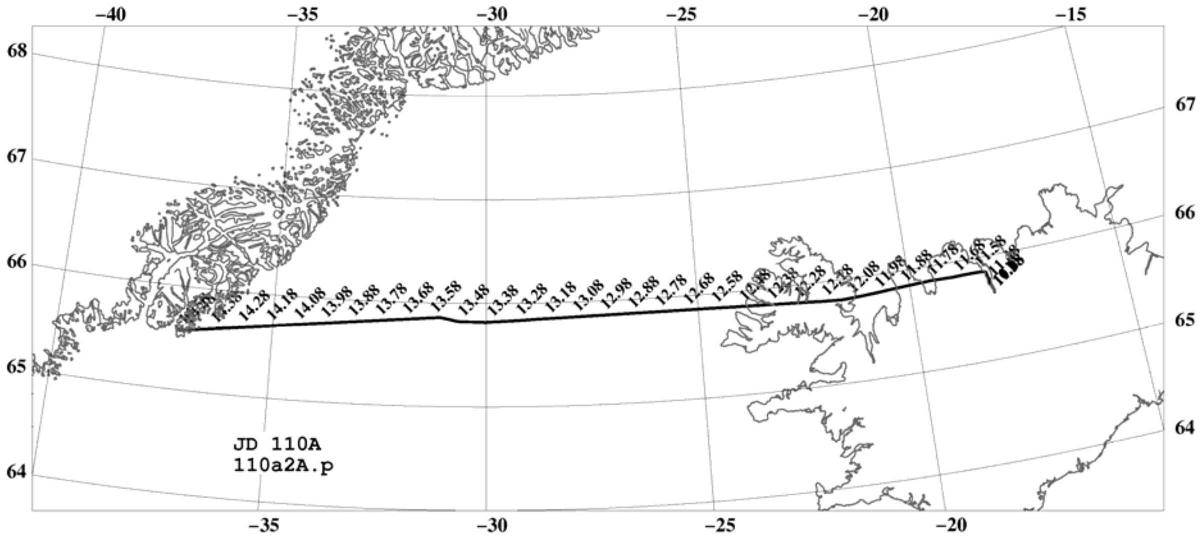
1458	Take off YEU	2138	On ground DMH
1644	On ground NAQ		
		ASIRAS LOG	
1733	Take off NAQ	1730	Internal calibration
180100	New scanner file	1735	Start record A120406_00.log
185900	New scanner file	1844	Start record A120406_01.log
195930	New scanner file	1944	Start record A120406_02.log
2056	Climb due to clouds	2049	Start record A120406_03.log
	Stop scanner	2100	Stop record, internal calibration

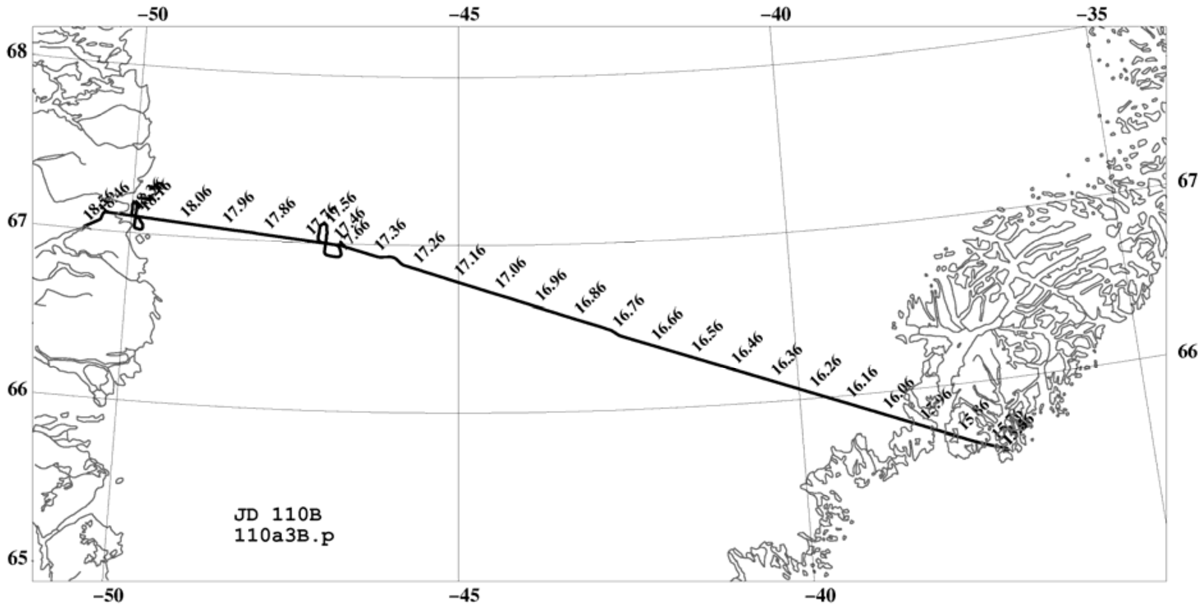




JD 110, 19-04-2012 AEY-IceSAR-KUS, KUS-IceSAR-SFJ

1124	Take off Akureyri
	Sea ice
133300	New scanner file, altitude 500m
1431	On ground Kulusuk
1540	Take off KUS
160300	New scanner file, altitude 500m
1831	On ground SFJ





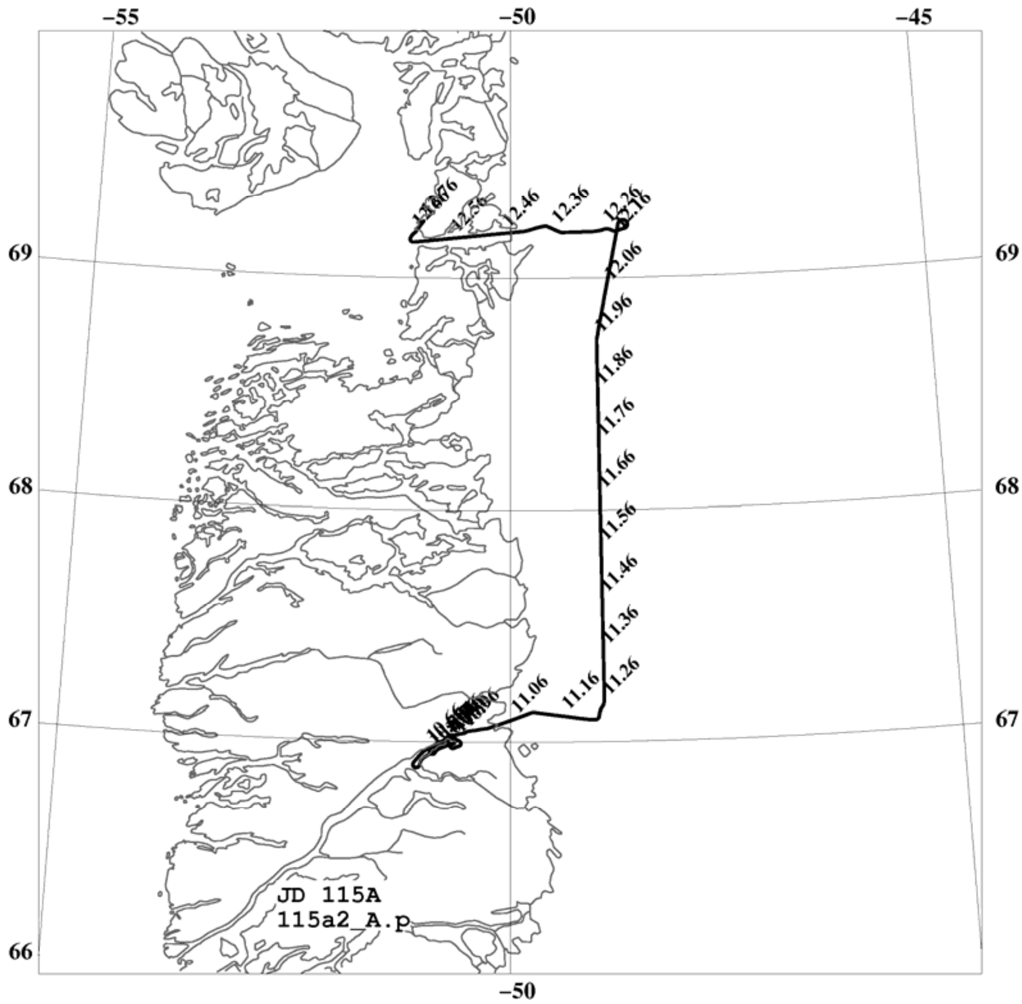
JD 115a, 24-04-2012 SFJ-SOWE-JAV

1021	Engines on
102200	New scanner file
102650	Taxi
1030	Take off SFJ
104155	RW
105000	Cross over blue building
1053	Lake
105440	Building S-N, towards SOWE3, high thin clouds
110800	New scanner file
111640	SOWE3
1137	SOWE4
115730	SOWE5
120630	New scanner file
1209	NOWE1, tear drop turn JAHG3-JAHG4, broken clouds
1223	Glacier front
122440	JAHG5
1238	Break line, end scanner file
1242	Landing JAV

ASIRAS LOG

Startup system
Internal calibration
New record A120424_00.log

1059	New record 01.log
1102	Glacier
1110	Error message; Comm problem with radar serial link def. Restart ASIRAS
1119	New record 02.log
1211	New record 03.log
1226	Turn off ASIRAS
1242	On ground JAV

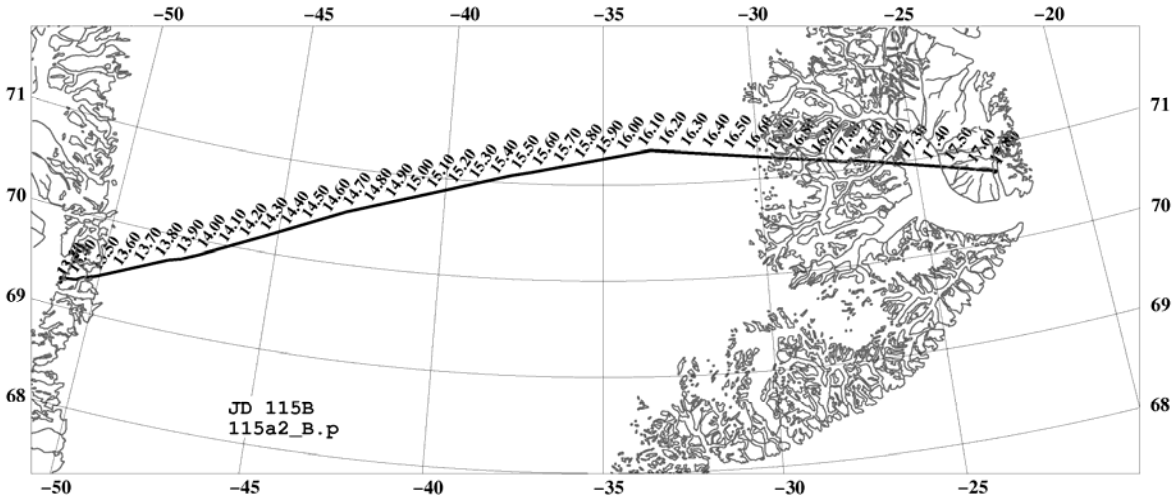


JD 115b, 24-04-2012 JAV-EGIG-CNP

1312	Engine on
1315	Taxi
131740	Take off JAV
131900	New scanner file (2 sec late start?)
1330	On line JAV-T1
1350	T1, high thin clouds
1354	T3
1359	T5
140900	New scanner file (1 sec early?)
1418	T12
1441	T21
150730	New scanner file
1528	T41
1533	EG5
1608	EG6
160900	New scanner file (closed 1646)
164630	New scanner file (no survey)
174340	Landing CNP

ASIRAS LOG

1325	Start record 120424_04.log
1333	New record 120424_07.log
1430	New record 120424_08.log
1530	New record 120424_09.log
1630	New record 120424_10.log



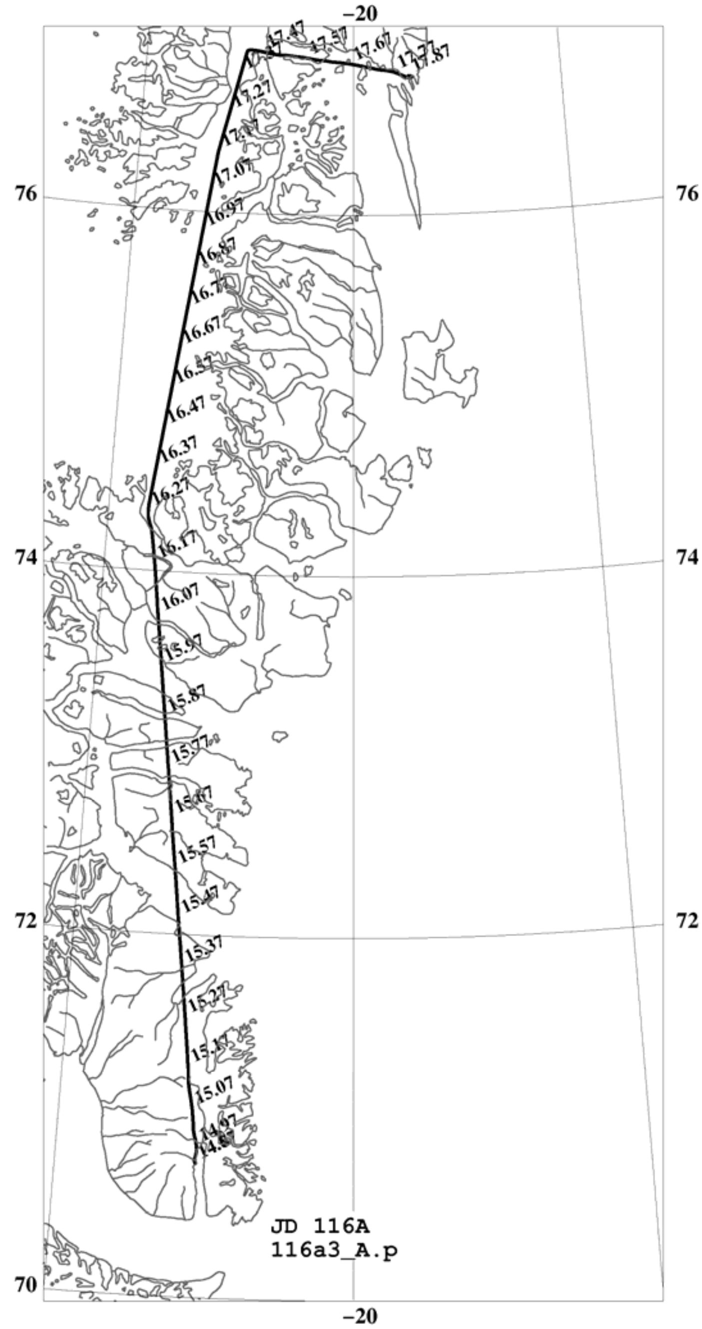
JD 116a, 25-04-2012 CNP-B-DMH

1449	Engines on
1451	Taxi
1455	Take off CNP
161000	New scanner file
1617	B1
170200	New scanner file
1710	B2
1725	B3
1750	Landing DMH

ASIRAS LOG

Internal calibration

1624	Start record, 120425_00.log
1724	New record 01.log



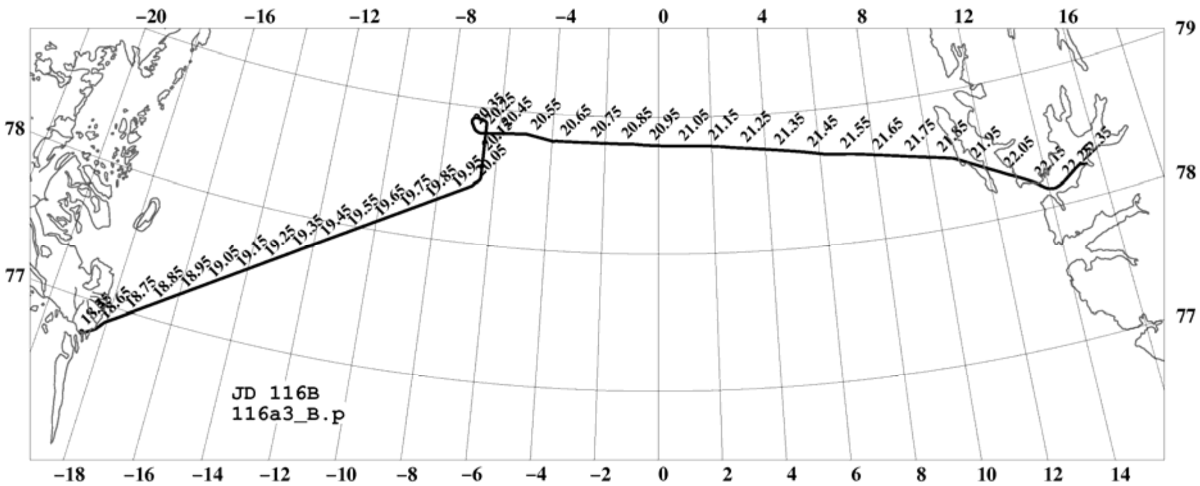
JD 116b, 25-04-2012 DMH-ULS-LYR

1827	Engine on
1829	Taxi
1833	Take off DMH
184630	New scanner file (after PC restart)
185230	Large refrozen lead, end of fast ice
194800	New scanner file, speed 120 knt
2004	ULS4 line start
2014	ULS4
201620	Left turn to ULS4-ULS3
2023	ULS4
2031	ULS3
2037	ULS2
2039	Large ice free area, polynia, clouds
2042	ULS1
2050	Ice edge, end scanner file (78N 48, 1W 30)
2222	Landing LYR

ASIRAS LOG

Internal calibration

1840	New record 02.log
1940	New record 03.log
2040	New record 04.log



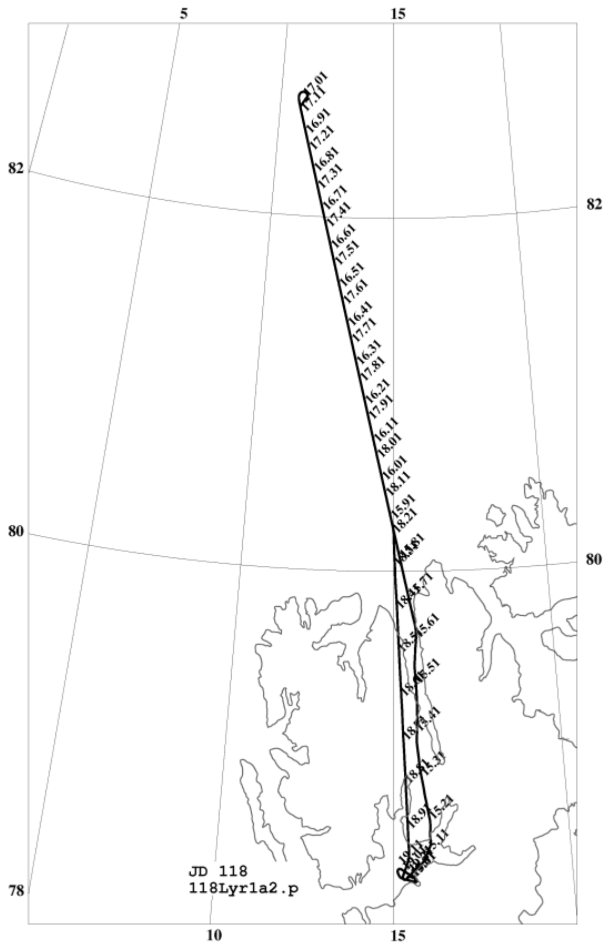
JD 118 27-04-2012 LYR-CryoSat-2 10885-LYR

1452	Engines on
1457	Taxi
1501	Take off LYR
153400	New scanner file, 500m alt
1540	885_1, open water in fjord
1553	885_2, open water, clouds
1555	Broken floes, 80N 19
	Wind and small waves on open water
1606	885_3
161050	Refrozen lead
1619	885_4
162000	New scanner file
1632	885_5
1645	885_6
165445	Open lead east
165630	Open lead E-W
1658	885_7, end of line
1701	EMAP restart (2 identical points!)
1706	885_7
170700	New scanner file
1719	885_6
1732	885_5
1745	885_4
1758	885_3
1810	Close scanner file, end of sea ice
19	RW
1915	Landing LYR

ASIRAS LOG

Internal calibration

	A120427_00
1552	New record A120427_01.log
1605	Event 1, open water
1619	SDS2, lead
1702	New record 02.log
1745	CryoSat-2, Event 1
1810	Stop log file
	Calibration flight runway LYR
1852	New record 03.log
1859	New record 04.log
1900	At 300m altitude
1902	Runway LYR, event 1
1903	New record file 05.log
1909	Runway, event 2
	Stop record
	“Ctrl+alt+del” to stop Asicc.exe



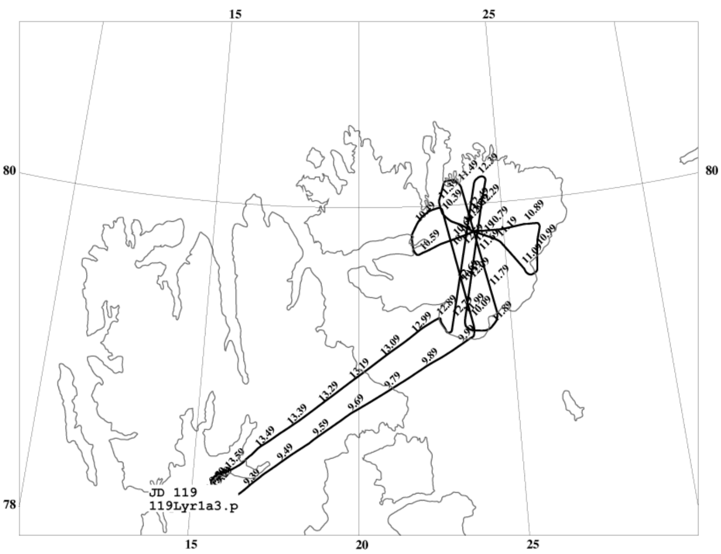
JD 119, 28-04-2012 LYR-Austfonna-LYR

0905	Engines on
090945	Taxi
0914	Take off LYR
095700	Scanner file start
1004	5_8_5, patches of clouds on line
1018	CR2 ~5m
1024	5_8_11, cloudy
1036	ETON_1
1037	CR1 ~5m?
1040	CR2 good?
1044	CR4 +-1-2m
1054	SV7, cloudy SV4-SV7
105530	New scanner file
1105	NV11
1115	CR4 2m
1120	NV1
1130	5_6_12
1137	CR4 5m cloudy
1150	5_6_6
115050	Ice edge
	Restart scanner pc
115730	New scanner file
1200	4_11
1216	CR5 +-0m
1217	4_1
1225	5_13_8
123245	CR3 -2-3m
1248	5_13_15, extend line to edge
124820	end line
1254	Close scanner file
1342	Landing LYR

ASIRAS LOG

Internal calibration

0953	Start record 00.log
1000	Icecap
	New log file 01.log
	Line CryoSat-2 May 8
	Corner reflector X_ETON_0805
1024	End of line CryoSat-2 May 8
	New log file 02.log, turn
1033	New log file 03.log
	Line SW Eton
1037	Corner reflector ETON2
	Corner reflector X_ETON_0805, SDS 03-04
	Corner reflector X_ETON_0513
	Corner reflector X_ETON_0506
1055	End of line SW Eton, stop record
1102	New record 04.log
	Line NW Hartog
	Corner reflector X_ETON_0506
1121	End of line NW Hartog
1129	New log file 05.log
	Line CryoSat-2 May 6
1151	End of line CryoSat-2 May 6
~1158	New record 06.log
	Line 492
1218	End of line 492, stop record
1224	New record 07.log
	Line CryoSat-2 May 13
1233	Corner Reflector X_ETON_0513
	Stop measurement



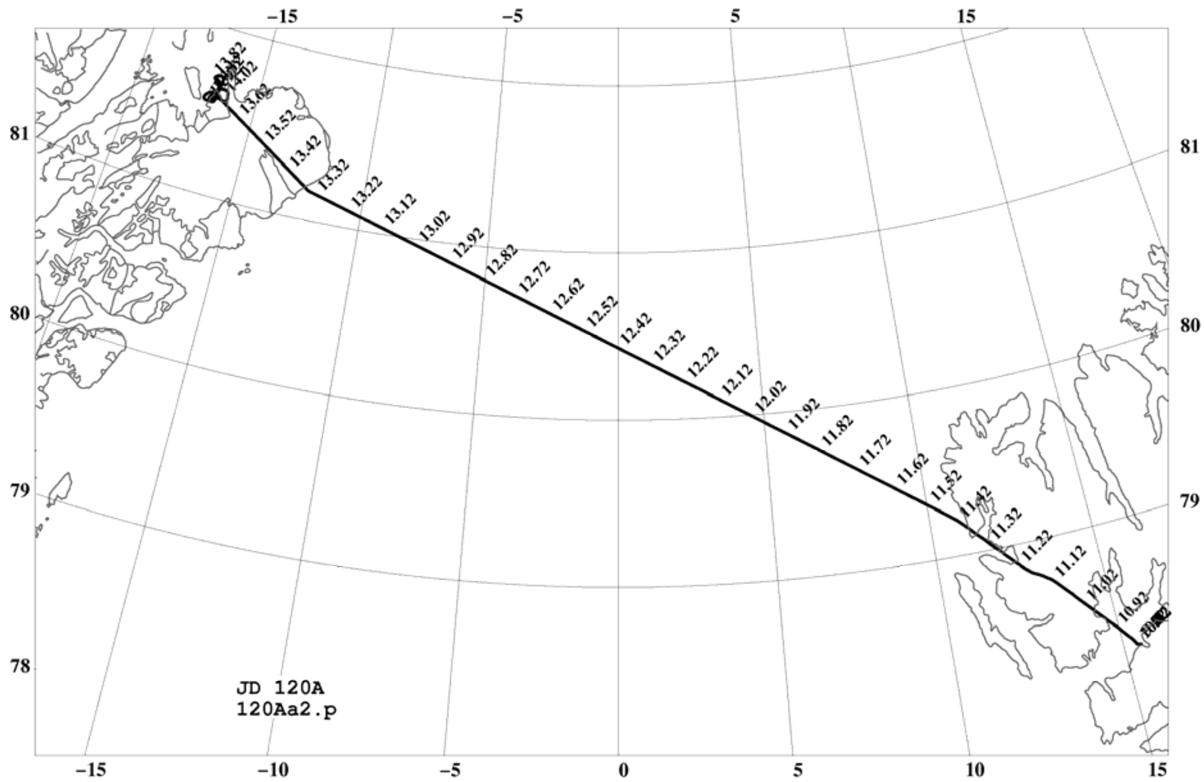
JD 120a, 29-04-2012 LYR-Kongsvegen-ENV-STN

093230	Scanner sync
1037	Engines on
104430	Taxi
1050	Take off LYR
105130	Scanner file start
	Kongsvegen (WP as 2006)
1113	KV1
111345	Glacier front
1120	Close scanner file
1126	EN7
114130	New scanner file
1147	Sea ice margin 79N41 7E18
114920	300m altitude
1208	9-10 ice conc, whales!
124700	New scanner file (1 sec late)
	Open water 5-8nm from EN8, 81 8.5-8.9
	11 23-27

1321	EN8
1322	Fast ice 81N12 12W23
1328	Coast line
1341	End line
1346	RW
135330	RW 2nd
135?	Ebbes koldhal
140440	Ebbes koldhal 2nd
1408	Landing STN

ASIRAS LOG

~11	New record, Kongsvegen
1146	New record
1249	New record
1343	New record, runway overflight STN



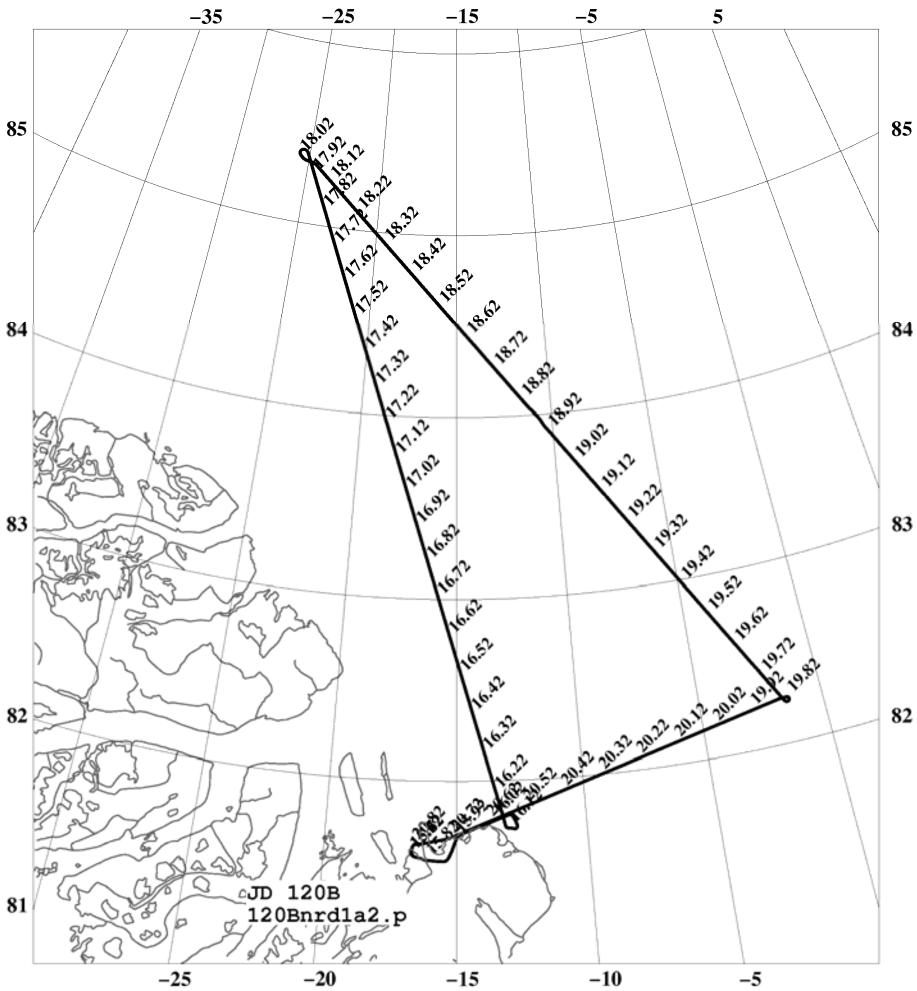
JD 120b, 29-04-2012 STN-CryoSat-2 10915-F-STN

AIR2 few satellites???

1536	Engines on
1539	Taxi
1546	Take off STN
154700	Scanner file start
1602	915_1 Tear drop turn
1609	915_1
1622	915_2
162230	New scanner file
1635	915_3
164020	CryoSat-2 pass!
1648	915_4
1703	915_5, clouds on/off
1717	915_6
171800	New scanner file
173200	915_7
1746	915_8
1758	915_9, tear drop turn
1803	On line F2-F1
180630	New scanner file
190530	New scanner file
1947	F1, tear drop turn
1950	On line F1-STN
200200	New scanner file, few sec late
2051	Landing STN

ASIRAS LOG

~1600	New record CryoSat-2 track
1709	New record
1803	Stop record, data backup
1808	New record, 06.log
1845	Lead grey/white ice, SDS 1
1923	New record 07.log
1948	New record 08.log, WP F1
2043	Stop record

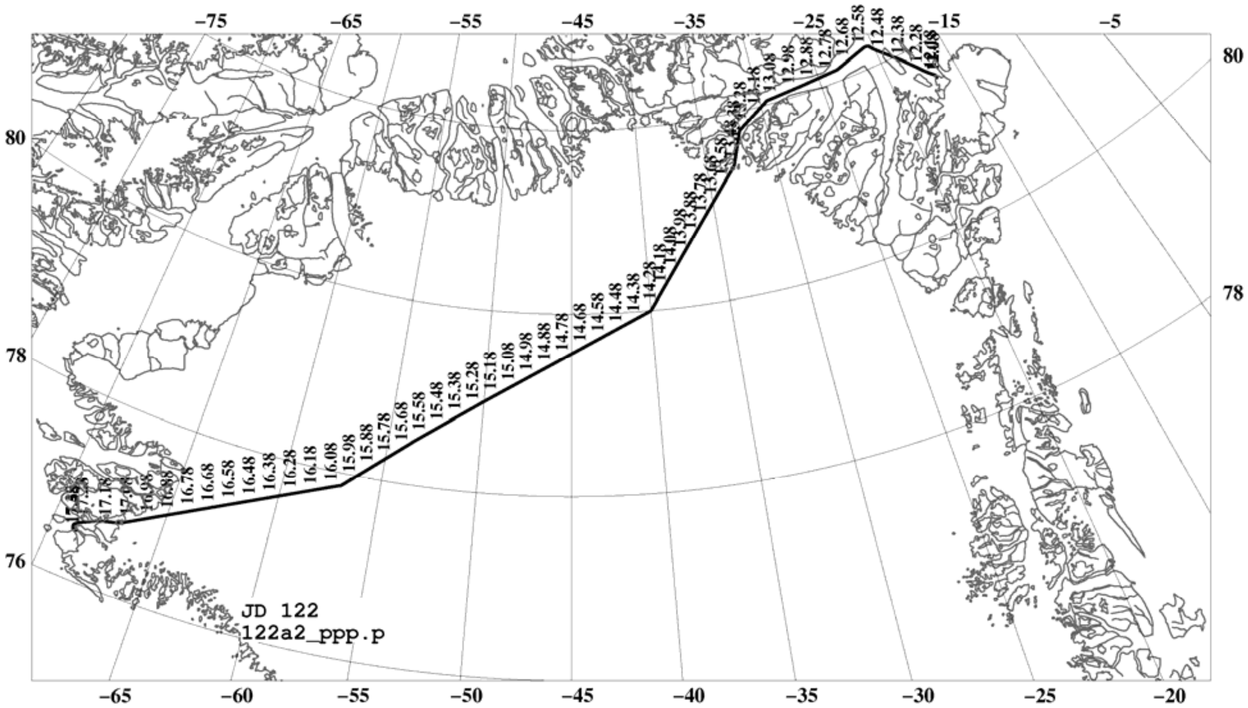


JD 122, 01-05-2012 STN-H-ICE-TAB

1202	Engines on
1205	Taxi
1210	Take off STN
121000	Scanner file start, no survey to H1
1231	AIR3 re-start, ant. plug was out!
123230	New scanner file for Indep. Fjord
1244	H1
1255	H2
1306	H4
131600	New scanner file
1318	Glacier front
1329	H6
140900	New scanner file
1418	ICE1
151000	New scanner file
1514	CR (pos. from 2008)
1538	ICE3
16	ICE4
16	New scanner file
16	End line
1723	Landing TAB

ASIRAS LOG

1210	Airborne
1234	Start record, H1-H2
1344	New record
1500	New record
1600	New record
1708	Stop measurement
	Internal calibration

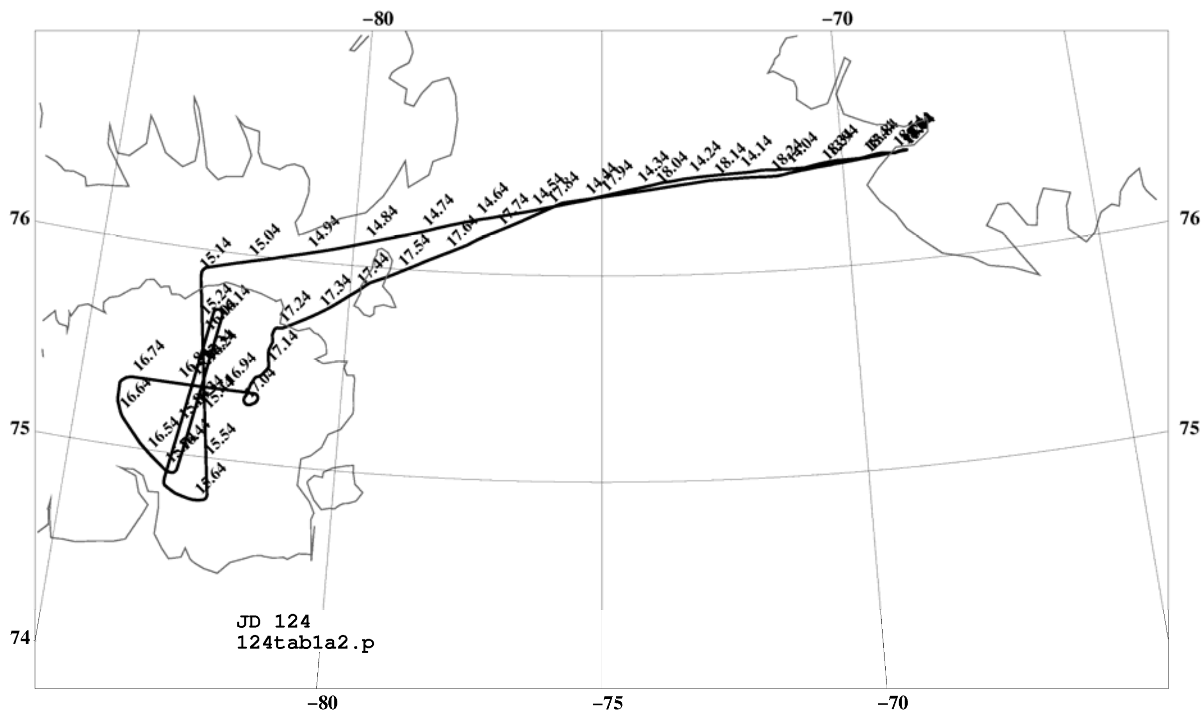


JD 124, 03-05-2012 TAB-DEVON-TAB

1336	Taxi
1344	Take off TAB
1509	On line CryoSat-2 May 3, North
151230	New scanner file
1536	End of line May 3, South
1544	On line CryoSat-2 April 22, South
1605	End of line April 22, North
160630	New scanner file
1608	On ASIRAS line 623, North
161654	Corner reflector at summit, ASIRAS ok
1628	End of line 623, South
1644	On ASIRAS line 450, West
1653	Corner reflector at summit, ASIRAS ok
1700	End of line 450, East
170030	New scanner file
1703	Belcher, South
1714	End of Belcher, North
1834	On ground TAB

ASIRAS LOG

1354	Internal calibration
1509	CryoSat-2 track May 3
	Start measurement
1524	SDS 1 and 2, nothing to see ?!?
1537	New record, new line
1608	New line
1615	CR hit, SDS 1_02.sds
1642	New kube
1715	Stop measurement, internal calibration

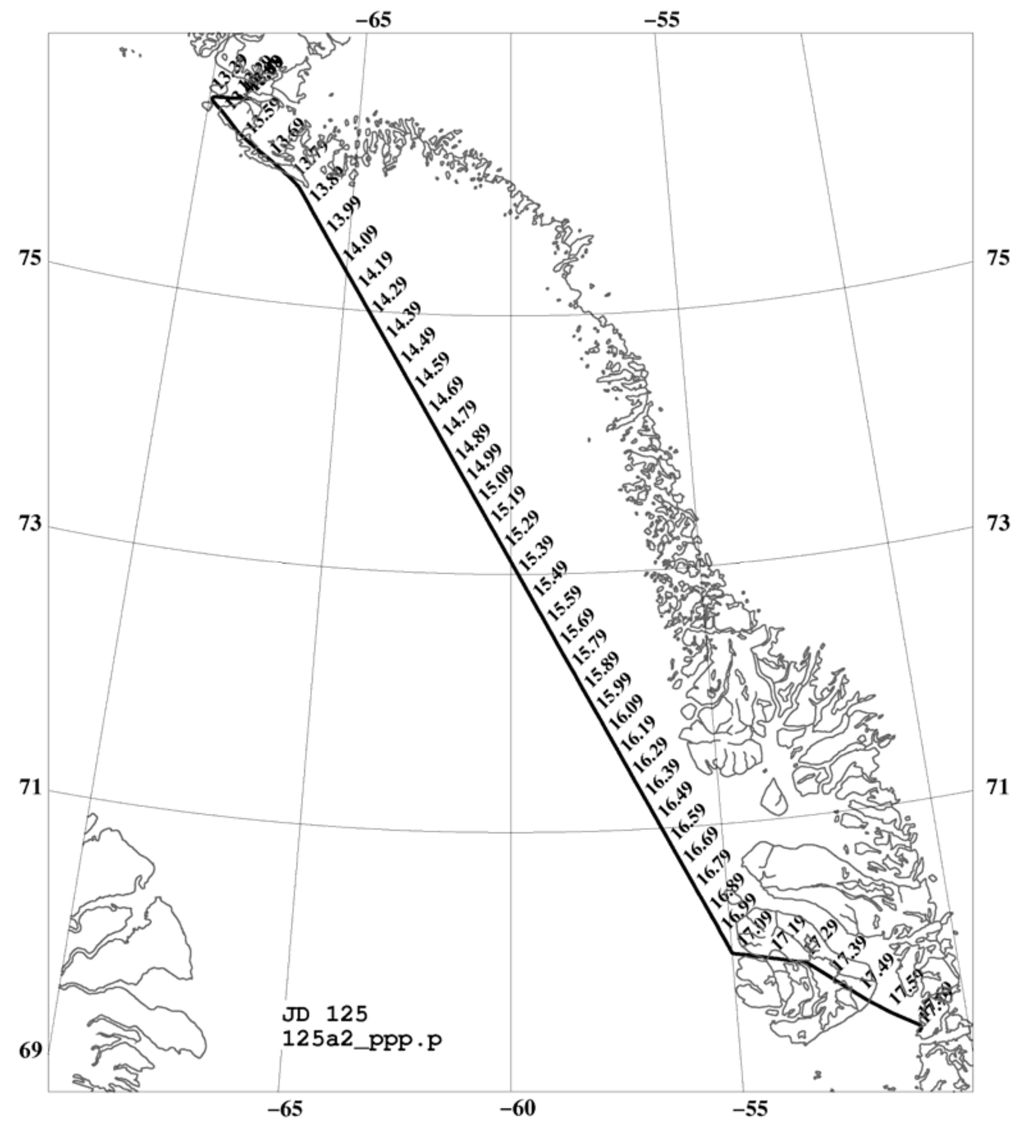


DOY 125, 04-05-2012 TAB-BAFFIN-DISKO-JAV

1306	Taxi
1314	Take off TAB
140830	New scanner file
1426	Low thin clouds
1440	Stop logging scanner
1455	Climbiung due to icing
153900	New scanner file
~1546	No scanner file
1612	Stop logging
162230	New scanner file, 200m
1649	Ice edge
165300	New scanner file
	Climb, break the line
1656	Stop logging
	Skip Disko due to clouds
1743	On ground JAV

ASIRAS LOG

1410	Internal calibration
	Start measurement log
1430-36	Low clouds (no ALS)
1454	Ascend due to icing
	Stop measurement
1539	Descend
	New measurement log
	Disko, clouds, no measurement

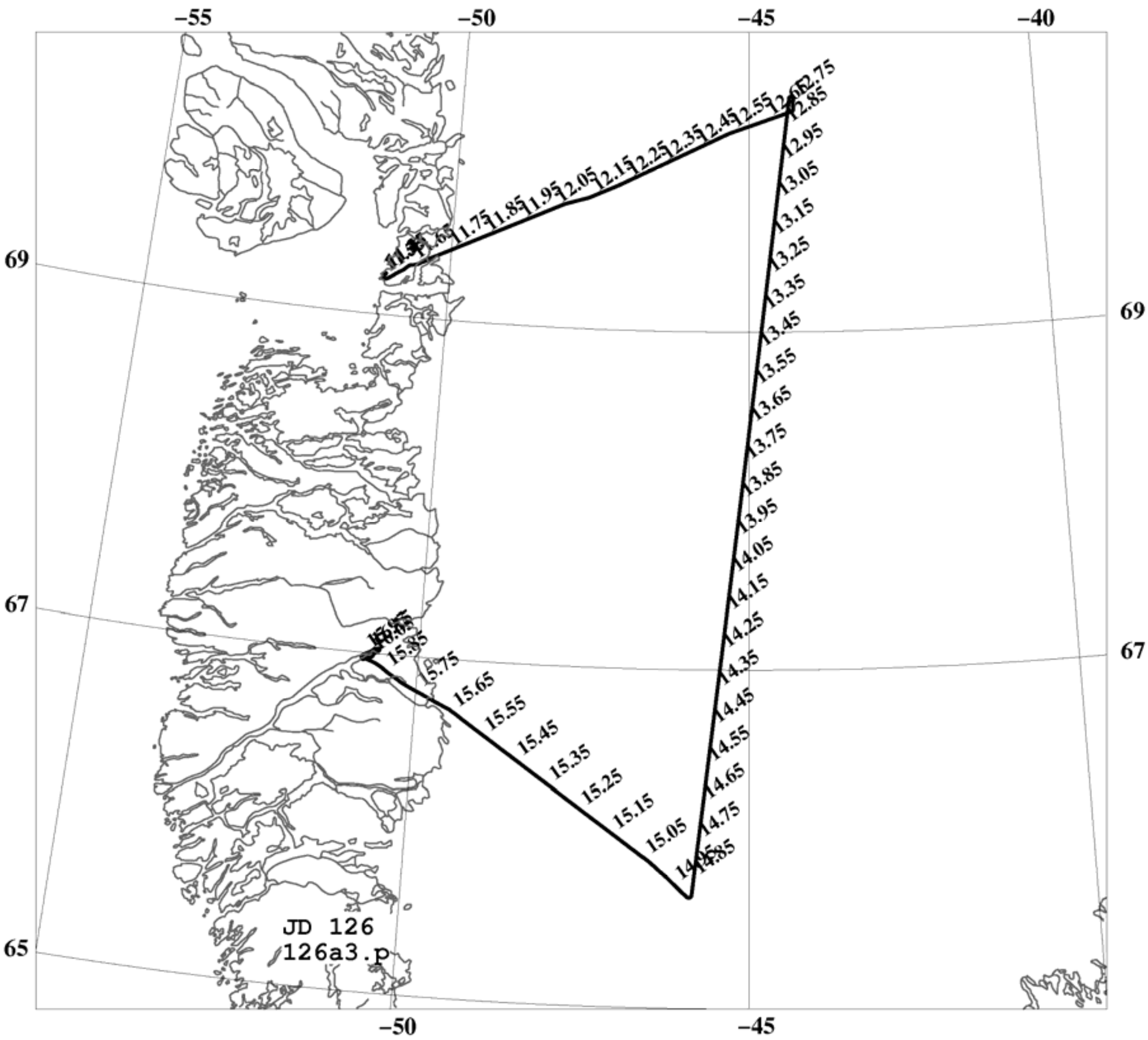


DOY 126, 05-05-2012 JAV-CryoSat-2 11098-CAL-SFJ

1132	Take off JAV
113300	New scanner file
	Poor visibility
124300	New scanner file
134130	New scanner file
1453	end of line 11098
	calibration flight SFJ
154630	New scanner file, CAL
1557	Runway overflight
160054	Building E-W
160330	Building S-N
1609	On ground SFJ

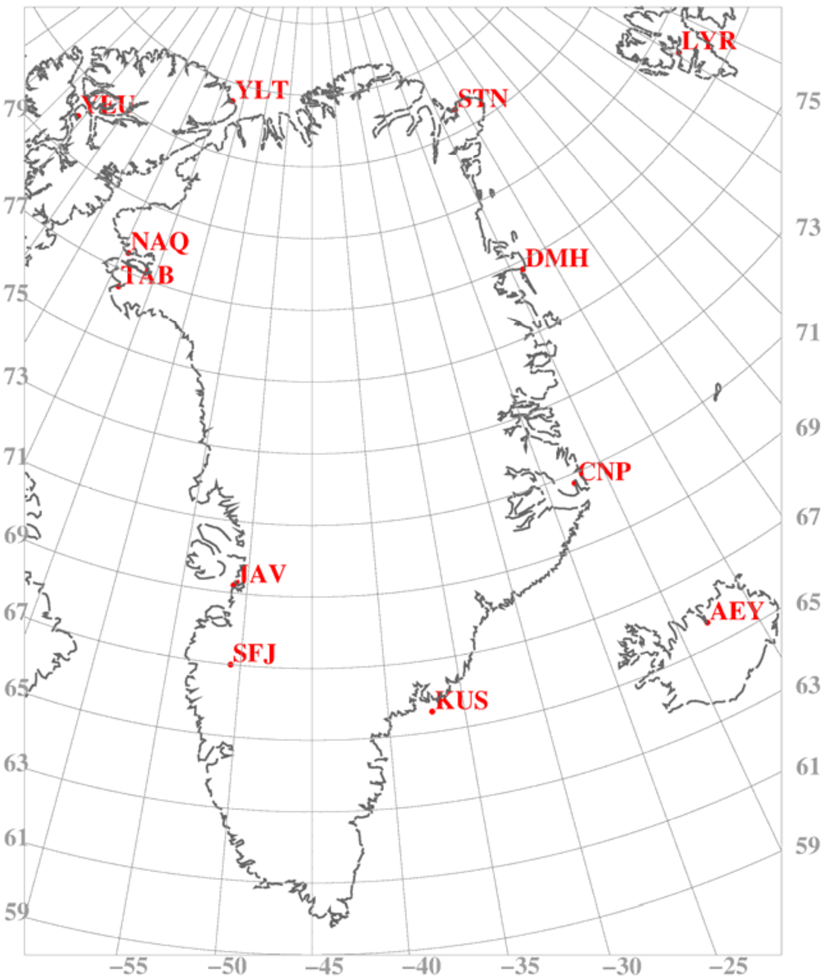
ASIRAS LOG

1136	Take off JAV
	internal calibration
1143	Start measurement
1243	Stop record
1245	New line, CryoSat-2 track 11098
1453	End of CryoSat-2 track
1454	Internal calibration
1552	Start measurement
	Calibration flight over runway SFJ,
	event 0
1600	Internal calibration
	Shut down system



2 APPENDIX Airport codes

IATA		Location	Land	Latitude	Longitude
AEY		Akureyri	Iceland	65.659994	-18.072703
CNP		Constable Pynt	Greenland	70.7444	-22.6482
n/a	DMH	Danmarkshavn	Greenland	76.7704	-18.6581
JAV		Ilulissat	Greenland	69.217	-51.083
KUS		Kulusuk	Greenland	65.573611	-37.123611
LYR		Longyearbyen	Norway	78.2456	15.4991
NAQ		Qaanaaq	Greenland	77.50	-69.25
n/a	STN	Station Nord	Greenland	81.5971	-16.6569
SFJ		Kangerlussuaq	Greenland	67.006	-50.703
THU		Thule AB	Greenland	76.53	-68.71
YEU		Eureka	Canada	79.994444	-85.811944
YLT		CFS Alert	Canada	82.500	-62.325



3 APPENDIX Coordinates of GPS base stations

Date	DOY	Reference	Latitude (DMS)	Longitude (DMS)	Ellipsoidal Height (m)
25-03-2012	085	AEY1	65 39 08.42213	-18 04 24.06460	67.483
25-03-2012	085	AEY2	65 39 08.44690	-18 04 24.32016	67.444
29-03-2012 03-04-2012	Av. (089-095)	YLT1	82 30 44.61908	-62 19 56.02134	51.668
30-03-2012	090	YLT2	82 30 44.61912	-62 19 56.02092	51.672
05-04-2012	096	YEU2	79 59 25.80989	-85 56 22.59214	17.766
20-04-2012	111	SFJ1	67 00 38.19227	-50 41 36.31478	68.572
21-04-2012	112	SFJ1	67 00 17.35063	-50 42 27.91264	67.320
21-04-2012	112	SFJ2	67 00 18.38117	-50 42 20.92333	63.130
27-04-2012	118	LYR1	78 14 45.10068	15 30 18.34718	54.013
27-04-2012	118	LYR2	78 14 45.53670	15 30 14.73705	54.220
28-04-2012	119	LYR1	78 14 45.60380	15 30 13.97667	54.294
28-03-2012 28-04-2012	Av. (088-119)	STN3	81 36 04.91659	-16 39 42.91807	67.480
29-04-2012	120	STN1	81 35 46.66273	-16 39 29.13278	61.914
29-04-2012	120	STN2	81 35 46.47486	-16 39 28.49946	62.083
03-05-2012	124	THU1	76 32 02.00395	-68 45 41.64270	62.679
03-05-2012	124	THU2	76 32 01.98752	-68 45 42.84798	62.451

4 Appendix – Overview of acquired ALS data

Date	DOY	Raw ALS file	Start time (dechr)	Stop time (dechr)	Angles (pitch, roll, heading)	dt (s)	Scan width limits
25-03-2012	85	85_110500.2dd	11.08349	11.59480			
26-03-2012	86	86_131500.2dd	13.25009	13.44759	-1.6 -0.11 0.0	0	45 230
		86_142400	14.39959	14.87535	-1.58 -0.09 4.75	2	45 230
		86_151630.2dd	15.27451	16.12397	-1.58 -0.09 4.75[1)]	2	45 230
					-1.6 -0.11 0.0[1)]	2	45 230
		86_160800.2dd	16.13291	16.95040	-1.6 -0.11 0.0	2	45 230
27-03-2012	87	87_111900.2dd	11.31675	12.58380	-1.6 -0.13 0.0	0	60 210
		87_123600.2dd	12.60011	13.13415	-1.6 -0.13 0.0	0	55 230
		87_130830.2dd	13.14176	14.13702	-1.6 -0.13 0.0	0	55 230
		87_140900.2dd	14.15009	14.86291	-1.6 -0.13 0.0	0	60 160
28-03-2012	88				No data	-	-
29-03-2012	89	89_121030.2dd	0.03333	0.28840	No data	-	-
		89_130400.2dd	0.08081	0.99886	-1.6 -0.06 0.0	4147	45 175
		89_140730.2dd	14.12512	15.22122	-1.6 -0.06 0.0	0	45 175
		89_151400.2dd	15.23343	16.28812	-1.6 -0.06 0.0	0	45 175
		89_161800.2dd	16.30014	16.97814	-1.6 -0.06 0.0	0	45 175
30-03-2012	90	90_120945.2dd	12.16263	12.23154	Too few data	-	-
		90_130500.2dd	13.08348	14.12260	-1.6 -0.06 0.0	0	45 190
		90_140830.2dd	14.14181	14.51315	-1.6 -0.06 0.0	0	45 200
		90_143230.2dd	14.54176	14.87452	-1.6 -0.06 0.0	0	45 230
		90_154830.2dd	15.80846	16.63715	-1.6 -0.06 0.0	0	45 190
		90_163900.2dd	16.65012	17.45392	-1.6 -0.06 0.0	0	45 190
		90_172800.2dd	17.46677	18.54030	-1.6 -0.06 0.0	0	45 190
02-04-2012	93	93_122000.2dd	12.33343	13.30738	-1.6 -0.10 0.0	0	45 190
		93_131900.2dd	13.31680	14.25900	-1.6 -0.10 0.0	0	45 195
		93_141600.2dd	14.26679	15.11975	-1.6 -0.10 0.0	0	45 200
		93_150800.2dd	15.13341	16.12875	-1.6 -0.10 0.0	0	45 200
		93_160830.2dd	16.14176	17.03199	-1.6 -0.10 0.0	0	45 225
		93_170300.2dd	17.05007	17.48346	-1.6 -0.10 0.0	0	45 230
03-04-2012	94	94_140400.2dd	14.06676	15.00009	-1.6 -0.10 0.0	0	45 195
		94_150030.2dd	15.00843	15.99413	-1.6 -0.10 0.0	0	45 200
		94_160030.2dd	16.00844	16.97736	-1.6 -0.10 0.0	0	45 200
		94_165900.2dd	16.98341	18.03197	-1.6 -0.10 0.0	0	45 225
		94_180300.2dd	18.05009	18.56713	-1.6 -0.10 0.0	0	45 230
04-04-2012	95	95_160600.2dd	16.10010	17.17738	-1.6 -0.10 0.0	0	45 165
		95_171100.2dd	17.18344	17.96695	-1.6 -0.10 0.0	0	45 180
		95_180400.2dd	18.06675	18.98223	-1.6 -0.10 0.0	0	45 210
		95_185930.2dd	18.99178	19.47226	-1.6 -0.10 0.0	0	45 220

Date	DOY	Raw ALS file	Start time (dechr)	Stop time (dechr)	Angles (pitch, roll, heading)	dt (s)	Scan width limits
05-04-2012	96	96_155000.2dd	15.83345	16.71471	-1.6 -0.14 0.0	0	45 155
		96_164500.2dd	16.75010	16.80973	Too few data 2)	-	-
		96_170000.2dd	17.00010	17.07927	Too few data 2)	-	-
		96_171030.2dd	17.17509	18.07957	-1.6 -0.14 0.0	0	45 220
		96_180530.2dd	18.09176	18.99998	-1.6 -0.14 0.0	0	45 220
		96_190030.2dd	19.00842	19.33104	-1.6 -0.14 0.0	0	45 230
06-04-2012	97	97_180100.2dd	18.01677	18.97160	-1.6 -0.14 0.0	0	45 180
		97_185900.2dd	18.98340	19.97469	-1.6 -0.14 0.0	0	45 230
		97_195930.2dd	19.99176	20.94883	-1.6 -0.14 0.0	0	45 230
19-04-2012	110A	110_133300.2dd	13.55008	14.46325	-1.6 -0.10 0.0	0	45 230
19-04-2012	110B	110_160300.2dd	16.04596	17.47266	-1.6 -0.10 0.0	0	45 230
24-04-2012	115	115_102200.2dd	10.36679	11.12194	-1.6 -0.10 0.0	0	45 230
		115_110800.2dd	11.13339	12.09527	-1.6 -0.10 0.0	0	45 230
		115_120630.2dd	12.10847	12.70051	-1.6 -0.08 0.0	0	45 230
		115_131900.2dd	13.31723	14.13877	-1.6 -0.08 0.0	0	45 230
		115_140900.2dd	14.14990	15.11414	-1.6 -0.08 0.0	0	45 230
		115_150730.2dd	15.12514	16.13771	-1.6 -0.08 0.0	0	45 230
		115_160900.2dd	16.15015	16.76215	-1.6 -0.08 0.0	0	45 230
		115_164630.2dd	16.77635	16.80912	Too few data	-	-
25-04-2012	116	116_161000.2dd	16.16678	17.02031	-1.6 -0.07 0.0	0	45 230
		116_170200.2dd	17.03345	17.74734	-1.6 -0.07 0.0	0	45 230
		116_184630.2dd	18.77515	19.78941	-1.58 -0.22 -4.75 3)	0	45 230
		116_194800.2dd	19.80030	20.86147	-1.6 -0.07 0.0	0	45 230
27-04-2012	118	118_153400.2dd	15.56678	16.32354	-1.5 -0.06 0.0	0	45 230
		118_162000.2dd	16.33330	17.10377	-1.5 -0.06 0.0	0	45 230
		118_170700.2dd	17.11679	18.17014	-1.5 -0.06 0.0	0	45 230
		118_185400.2dd	18.90014	19.18661	-1.5 -0.06 0.0	0	45 230
28-04-2012	119	119_095700.2dd	09.95014	10.91701	-1.5 -0.06 0.0	0	45 230
		119_105530.2dd	10.92520	11.85056	-1.5 -0.06 0.0	0	45 230
		119_115730.2dd	11.95845	12.89844	Stripes		
29-04-2012	120	120_105130.2dd	10.85847	11.33117	-1.5 -0.04 0.0	0	45 230
		120_114130.2dd	11.69179	12.77837	-1.5 -0.04 0.0	0	45 230
		120_124700.2dd	12.78379	14.14635	-1.5 -0.04 0.0	0	45 230
		120_154700.2dd	15.78347	16.36843	-1.5 -0.06 0.0	0	45 230
		120_162230.2dd	16.37513	17.28888	-1.5 -0.06 0.0	0	45 230
		120_171800.2dd	17.30015	18.09400	-1.5 -0.06 0.0	0	45 230
		120_180630.2dd	18.10843	19.08124	-1.5 -0.06 0.0	0	45 230
		120_190530.2dd	19.09178	20.02734	-1.5 -0.06 0.0	0	45 230
		120_200200.2dd	20.03516	20.85592	-1.5 -0.06 0.0	0	45 230
01-05-2012	122	122_121000.2dd	12.16679	12.53383	-1.5 -0.08 0.0	0	45 230
		122_123230.2dd	12.54177	13.25780	-1.5 -0.08 0.0	0	45 230
		122_131600.2dd	13.26676	14.14356	-1.5 -0.08 0.0	0	45 230
		122_140900.2dd	14.15008	15.15955	-1.5 -0.08 0.0	0	45 230
		122_151000.2dd	15.16677	16.07001	-1.5 -0.08 0.0	0	45 230
		122_160430.2dd	16.07511	17.11908	-1.5 -0.08 0.0	0	45 230
03-05-2012	124	124_151230.2dd	15.20848	16.09879	-1.5 -0.06 0.0	0	45 230
		124_160630.2dd	16.10844	17.00046	-1.5 -0.06 0.0	0	45 230
		124_170030.2dd	17.00843	17.34747	-1.5 -0.06 0.0	0	45 230

Date	DOY	Raw ALS file	Start time (dechr)	Stop time (dechr)	Angles (pitch, roll, heading)	dt (s)	Scan width limits
04-05-2012	125	125_140830.2dd	14.14175	14.68294	-1.5 -0.06 0.0	0	45 230
		125_153900.2dd	15.65010	16.22329	-1.5 -0.06 0.0	0	45 230
		125_162230.2dd	16.37509	16.87291	-1.5 -0.06 0.0	0	45 230
		125_165300.2dd	16.88342	16.94402	-1.5 -0.08 0.0	0	45 230
05-05-2012	126	126_113300.2dd	11.55009	12.70959	-1.5 -0.07 0.0	0	45 230
		126_124300.2dd	12.71678	13.68582	-1.5 -0.07 0.0	0	45 230
		126_134130.2dd	13.69179	14.88747	-1.5 -0.07 0.0	0	45 230
		126_154630.2dd	15.77509	16.08175	-1.5 -0.07 0.0	0	45 230

1) OxTS INS used before 15.33 UTC, Honeywell INS used after 15.33 UTC. OxTS angles fitted to Honeywell at 15.33 UTC
2) Too many clouds
3) OxTS INS used, no Honeywell INS for first part of flight. OxTS angles fitted to Honeywell at 19.50 UTC

5 Appendix – Overview of acquired ASIRAS log-files

Date	File name	Start time (UTC)	End time (UTC)	Range window (m)	# Pulses
25-03-2012	A120325_00.log	11:06:09	11:06:21	360.00	5000
	A120325_01.log	11:09:07	11:09:16	360.00	22182
	A120325_02.log	11:10:07	11:12:31	360.00	358586
	A120325_03.log	11:13:18	11:15:29	360.00	324999
	A120325_04.log	15:13:26	15:14:02	90.00	87500
26-03-2012	A120326_00.log	14:33:47	15:02:15	90.00	4259975
27-03-2012	A120327_00.log	11:26:20	12:36:44	90.00	10554935
	A120327_01.log	12:36:45	14:08:31	90.00	13759911
	A120327_02.log	14:08:39	14:53:20	90.00	6697457
28-03-2012	A120328_00.log	13:14:15	13:33:37	90.00	2899983
29-03-2012	A120329_00.log	12:27:00	13:27:50	90.00	10948312
	A120329_01.log	13:27:58	14:29:12	90.00	11023338
	A120329_02.log	14:29:14	15:41:58	90.00	13094152
	A120329_03.log	15:42:00	16:43:21	90.00	11044344
	A120329_04.log	16:43:23	16:57:20	90.00	2508987
30-03-2012	A120330_00.log	13:06:31	14:04:18	90.00	8662446
	A120330_01.log	14:04:20	14:49:33	90.00	6779956
	A120330_02.log	15:50:09	16:49:44	90.00	8932445
	A120330_03.log	16:49:45	17:53:34	90.00	9567437
	A120330_04.log	17:53:36	18:32:54	90.00	5889962
02-04-2012	A120402_00.log	12:12:00	13:20:34	90.00	10279937
	A120402_01.log	13:20:36	14:15:57	90.00	8297446
	A120402_02.log	14:15:59	15:14:23	90.00	8754943
	A120402_03.log	15:14:24	16:15:25	90.00	9147442
	A120402_04.log	16:15:26	17:26:33	90.00	10662432
03-04-2012	A120403_00.log	14:08:36	15:08:04	90.00	8914945
	A120403_01.log	15:08:05	16:08:05	90.00	8994941
	A120403_02.log	16:08:06	17:08:05	90.00	8992442
	A120403_03.log	17:08:06	18:11:55	90.00	9564938
	A120403_04.log	18:11:56	18:31:48	90.00	2974981
04-04-2012	A120404_00.log	15:54:29		90.00	
	A120404_01.log	17:09:15	18:09:08	90.00	8974942
	A120404_02.log	18:09:10	19:09:12	90.00	8999941
	A120404_03.log	19:09:14	19:28:57	90.00	2952481
05-04-2012	A120405_00.log	15:46:46	16:43:59	90.00	8577446
	A120405_01.log	16:44:01	17:44:49	90.00	9114940
	A120405_02.log	17:44:53	18:44:07	90.00	8879941
	A120405_03.log	18:44:10	19:22:13	90.00	5702462
06-04-2012	A120406_00.log	17:38:16	18:45:01	90.00	10009938
	A120406_01.log	18:45:03	19:44:00	90.00	8839944
	A120406_02.log	19:44:02	20:49:52	90.00	9872437
	A120406_03.log	20:49:54	20:59:39	90.00	1459990

Date	File name	Start time (UTC)	End time (UTC)	Range window (m)	# Pulses
24-04-2012	A120424_00.log	10:42:28	10:59:16	90.00	2514986
	A120424_01.log	10:59:20	11:12:14	90.00	2514986
	A120424_02.log	11:19:56	12:10:32	90.00	7584949
	A120424_03.log	12:11:03	12:38:30	90.00	4112474
	A120424_04.log	13:25:03	13:26:47	90.00	257499
	A120424_05.log	13:26:54	13:27:39	90.00	109999
	A120424_06.log	13:31:41	13:31:53	90.00	27500
	A120424_07.log	13:33:07	14:30:15	90.00	8567444
	A120424_08.log	14:30:19	15:30:11	90.00	8977440
	A120424_09.log	15:30:16	16:30:11	90.00	8984939
	A120424_10.log	16:30:45	16:44:38	90.00	2079987
25-04-2012	A120425_00.log	16:18:25	17:24:05	90.00	9847436
	A120425_01.log	17:24:17	17:27:16	90.00	442497
	A120425_02.log	18:41:29	19:40:09	90.00	8794944
	A120425_03.log	19:40:10	20:40:03	90.00	8977441
	A120425_04.log	20:40:27	20:52:14	90.00	1762489
27-04-2012	A120427_00.log	15:41:47	15:51:43	90.00	1484992
	A120427_01.log	15:52:14	17:02:15	90.00	10497431
	A120427_02.log	17:02:20	18:10:26	90.00	10212432
	A120427_03.log	18:52:11	18:59:30	90.00	1094994
	A120427_04.log	18:59:34	19:03:23	90.00	567497
	A120427_05.log	19:03:33	19:10:32	90.00	1042493
28-04-2012	A120428_00.log	09:53:13	10:01:13	90.00	1194993
	A120428_01.log	10:01:15	10:24:13	90.00	3439978
	A120428_02.log	10:29:36	10:31:46	90.00	319999
	A120428_03.log	10:33:42	10:55:22	90.00	3244979
	A120428_04.log	11:02:16	11:21:53	90.00	2937480
	A120428_05.log	11:29:45	11:51:42	90.00	3287478
	A120428_06.log	11:59:01	12:18:29	90.00	2914981
	A120428_07.log	12:24:55	12:49:24	90.00	3667476
29-04-2012	A120429_00.log	10:58:00	11:16:52	90.00	2827483
	A120429_01.log	11:46:21	12:49:23	90.00	9452438
	A120429_02.log	12:49:26	13:41:29	90.00	7804948
	A120429_03.log	13:43:49	13:56:40	90.00	1922487
	A120429_04.log	15:58:05	17:08:59	90.00	10632432
	A120429_05.log	17:09:01	18:04:08	90.00	8262445
	A120429_06.log	18:08:08	19:23:40	90.00	11324924
	A120429_07.log	19:23:59	19:48:16	90.00	3639976
	A120429_08.log	19:48:43	20:43:27	90.00	8207446
01-05-2012	A120501_00.log	12:34:21	13:44:41	90.00	10544933
	A120501_01.log	13:44:46	15:03:08	90.00	11749922
	A120501_02.log	15:03:21	16:00:46	90.00	8607446
	A120501_03.log	16:00:47	17:08:04	90.00	10087437
03-05-2012	A120503_00.log	15:08:19	15:37:32	90.00	4377472
	A120503_01.log	15:42:09	16:06:09	90.00	3597476
	A120503_02.log	16:07:34	16:28:41	90.00	3162479
	A120503_03.log	16:42:22	17:15:31	90.00	4967468

Date	File name	Start time (UTC)	End time (UTC)	Range window (m)	# Pulses
04-05-2012	A120504_00.log	14:09:30	14:54:54	90.00	6804957
	A120504_01.log	15:38:09	16:57:27	90.00	11887421
	A120504_02.log	17:11:48	17:12:30	90.00	100000
05-05-2012	A120505_00.log	11:43:15	12:43:53	90.00	9089942
	A120505_01.log	12:45:40	12:46:22	90.00	100000
	A120505_02.log	12:46:24	14:53:53	90.00	19114879
	A120505_03.log	15:51:26	15:59:57	90.00	1272492

6 APPENDIX ESA File name convention ESA data format

In general the filename contains a shortcut for the instrument and the start and stop time of the data file.

ASIRAS:
AS30AXX_ASIWL1BNNNN_SSSSSSSSSSSSSSS_PPPPPPPPPPPPPPP_0001.DBL

AS30AXX	ASIRAS (AS30), AXX number of data log
ASIWL1BNNNN	Level 1B data (L1B) processor version (NNNN)
SSSSSSSSSSSSSSS	Start time given as YYYYMMDDTHHMMSS
PPPPPPPPPPPPPPP	Stop time given as YYYYMMDDTHHMMSS

GPS
GPS_ANT_VER_SSSSSSSSSSSSSSS-PPPPPP_0001.DAT

ANT	GPS antenna R for rear, and F for front
VER	Version
SSSSSSSSSSSSSSS	Start time given as YYYYMMDDTHHMMSS
PPPPPP	Stop time given as HHMMSS

Inertial Navigation System (INS)
INS_ SSSSSSSSSSSSSSS-PPPPPP_0001.DAT

SSSSSSSSSSSSSSS	Start time given as YYYYMMDDTHHMMSS
PPPPPP	Stop time given as HHMMSS

Airborne laser scanner (ALS) full resolution
ALS_L1B_ SSSSSSSSSSSSSSS-PPPPPP.DAT

L1B	Level 1B data
SSSSSSSSSSSSSSS	Start time given as YYYYMMDDTHHMMSS
PPPPPP	Stop time given as HHMMSS

Airborne laser scanner (ALS) 5mx5m resolution
ALS_L1B_ D2_SSSSSSSSSSSSSSS-PPPPPP.DAT

L1B	Level 1B data
D2	Coarse resolution
SSSSSSSSSSSSSSS	Start time given as YYYYMMDDTHHMMSS
PPPPPP	Stop time given as HHMMSS

AEM data files
HEM_CMPID_SSSSSSSSSSSSSSS_PPPPPPPPPPPPPPP.dat

CMPID	Contains campaign name (3 letters + 2 digits of year), The id for the CryoVEx 2011 field campaign is given by CRV11.
SSSSSSSSSSSSSSS	Start time given as YYYYMMDDTHHMMSS
PPPPPPPPPPPPPPP	Stop time given as YYYYMMDDTHHMMSS

7 APPENDIX ESA data format

The following appendix has been adapted from Stenseng et al (2007). The format description for core products is taken from the "ASIRAS, product Description, Issue: 2.6.1" by Cullen (2010) and the users should refer to this document for detailed information. The definition of the types used in the binary files can be found in Table 15.

Table 13: Defintion of binary types used in the description of the file format

Type	Description	Size [Bytes]
uc	Unsigned character	1
sc	Signed character	1
us	Unsigned short integer	2
ss	Signed short integer	2
ul	Unsigned long integer	4
sl	Signed long integer	4
ull	Unsigned long long integer	8
sll	Signed long long integer	8
d	Double precision floating	8
f	Single precision floating	4
[n]	Array length n	

7.1 ASIRAS L1b

Processed L1b ASIRAS data is delivered in binary, big endian format as described by Cullen (2010) and Tables 16, 17 and 18.

The L1b product consists of two elements.

1. An ASCII header consisting of a main product header (MPH), a specific product header (SPH), and the data set descriptors (DSDs).
2. A binary, big endian measurement data set (MDS).

Table 14: ASIRAS main product header (MPH) format

Field #	Description	Units	Bytes	Format
	Product Identification Information			
#01	PRODUCT=	keyword	8	8*uc
	quotation mark (")		1	uc
	Product File Name		62	uc
	quotation mark (")		1	uc
	newline character	terminator	1	uc

Continued on next page

Field #	Description	Units	Bytes	Format
#02	PROC_STAGE=	keyword	11	11*uc
	Processing stage code: N = Near-Real Time T = Test O = OFF Line (Systematic) R = Reprocessing L = Long Term Archive		1	uc
	newline character	terminator	1	uc
#03	REF_DOC=	keyword	8	8*uc
	quotation mark (")		1	uc
	Reference DFCB Document describing the product		23	23*uc
	quotation mark (")		1	uc
	newline character	terminator	1	uc
#04	Spare		40	40*uc
	newline character	terminator	1	uc
Data Processing Information				
#05	ACQUISITION_STATION=	keyword	20	20*uc
	quotation mark (")		1	uc
	Acquisition Station ID Filled by blanks		20	Kiruna
	quotation mark (")		1	uc
	newline character	terminator	1	uc
#06	PROC_CENTER=	keyword	12	12*uc
	quotation mark (")		1	uc
	Processing Center ID code		6	PDS
	quotation mark (")		1	uc
	newline character	terminator	1	uc
#07	PROC_TIME=	keyword	10	10*uc
	quotation mark (")		1	uc
	Processing Time (Product Generation Time)	UTC	27	dd-MMM-yyyy hh:mm:ss.uuuuuu
	quotation mark (")		1	uc
	newline character	terminator	1	uc
#08	SOFTWARE_VER=	Keyword	13	13*uc
	quotation mark (")		1	uc
	Processor name, up to 8 characters, software version number followed by trailer blanks if any. If not used set to blanks		14	14*uc ProcessorName/VV.rr
	quotation mark (")		1	uc
	newline character	terminator	1	uc
#09	Spare (blank characters)		40	40*uc
	newline character	terminator	1	uc

Continued on next page

Field #	Description	Units	Bytes	Format
Information on Time of Data				
#10	SENSING_START=	keyword	14	14*uc
	quotation mark (")		1	uc
	UTC start time of data sensing. This is the UTC start time of the Input Level 0 Product. If not used set to 27 blanks	UTC	27	dd-MMM-yyyy hh:mm:ss.uuuuuu
	quotation mark (")		1	uc
	newline character	terminator	1	uc
#11	SENSING_STOP=	keyword	13	13*uc
	quotation mark (")		1	uc
	UTC stop time of data sensing. This is the UTC stop time of the Input Level 0 Product. If not used set to 27 blanks	UTC	27	dd-MMM-yyyy hh:mm:ss.uuuuuu
	quotation mark (")		1	uc
	newline character	terminator	1	uc
#12	Spare (blank characters)		40	40*uc
	newline character	terminator	1	uc
Orbit Information				
#13	PHASE=	keyword	6	6*uc
	Phase Code: phase letter (A, B, \...) If not used set to X		1	uc
	newline character	terminator	1	uc
#14	CYCLE=	keyword	6	6*uc
	Cycle number. If not used set to +000		4	%+04d
	newline character	terminator	1	uc
#15	REL_ORBIT=	keyword	10	10*uc
	Relative Orbit Number at sensing start time. If not used set to +00000		6	%+06d
	newline character	terminator	1	uc
#16	ABS_ORBIT=	keyword	10	10*uc
	Absolute Orbit Number at sensing start time. If not used set to +00000		6	%+06d
	newline character	terminator	1	uc
#17	STATE_VECTOR_TIME=	keyword	18	18*uc
	quotation mark (")		1	uc
	UTC state vector time It is filled properly in case of usage of FOS Predicted Orbit information otherwise it shall be set to 27 blanks	UTC	27	dd-MMM-yyyy hh:mm:ss.uuuuuu
	quotation mark (")		1	uc
	newline character	terminator	1	uc

Continued on next page

Field #	Description	Units	Bytes	Format
#18	DELTA_UT1=	keyword	10	10*uc
	Universal Time Correction: DUT1 = UT1 - UTC Not used for ASIRAS. It shall be set to +.000000	s	8	%+08.6f
	<s>	units	3	3*uc
	newline character	terminator	1	uc
#19	X_POSITION=	keyword	11	11*uc
	X position in Earth Fixed Reference. If not used set to +0000000.000	m	12	%+012.3f
	<m>	units	3	3*uc
	newline character	terminator	1	uc
#20	Y_POSITION=	keyword	11	11*uc
	Y position in Earth Fixed Reference. If not used set to +0000000.000	m	12	%+012.3f
	<m>	units	3	3*uc
	newline character	terminator	1	uc
#21	Z_POSITION=	keyword	11	11*uc
	Z position in Earth Fixed Reference. If not used set to +0000000.000	m	12	%+012.3f
	<m>	units	3	3*uc
	newline character	terminator	1	uc
#22	X_VELOCITY=	keyword	11	11*uc
	X velocity in Earth Fixed Reference. If not used set to +0000.000000	m/s	12	%+012.6f
	<m/s>	units	5	5*uc
	newline character	terminator	1	uc
#23	Y_VELOCITY=	keyword	11	11*uc
	Y velocity in Earth Fixed Reference. If not used set to +0000.000000	m/s	12	%+012.6f
	<m/s>	units	5	5*uc
	newline character	terminator	1	uc
#24	Z_VELOCITY=	keyword	11	11*uc
	Z velocity in Earth Fixed Reference. If not used set to +0000.000000	m/s	12	%+012.6f
	<m/s>	units	5	5*uc
	newline character	terminator	1	uc
#25	VECTOR_SOURCE=	keyword	14	14*uc
	quotation mark (")		1	uc
	Source of Orbit State Vector Record FP = FOS predicted DN = DORIS Level 0 navigator DP = DORIS precise orbit FR = FOS Restituted DI = DORIS Preliminary		2	2*uc
	quotation mark (")		1	uc
	newline character	terminator	1	uc

Field #	Description	Units	Bytes	Format
#26	Spare (blank characters)		40	40*uc
	newline character	terminator	1	uc
SBT to UTC conversion information				
#27	UTC_SBT_TIME=	Keyword	13	13*uc
	quotation mark (")		1	uc
	Not used and set to 27 blanks		27	27*uc
	quotation mark (")		1	uc
	newline character	Terminator	1	uc
#28	SAT_BINARY_TIME=	Keyword	16	16*uc
	Satellite Binary Time Not used for Cryosat and it shall be set to zeros		11	+0000000000
	newline character	Terminator	1	uc
#29	CLOCK_STEP =	Keyword	11	11*uc
	Clock Step Not used for Cryosat and it shall be set to zeros		11	+0000000000
	<ps>	Units	4	4*uc
	newline character	Terminator	1	uc
#30	Spare (blank characters)		32	32*uc
	newline character	Terminator	1	uc
Leap Second Information				
#31	LEAP_UTC=	Keyword	9	9*uc
	quotation mark (")		1	uc
	UTC Time of the occurrence of the leap second. If a leap second occurred in the product window the field is set by a devoted function in the CFI EXPLORER_ORBIT library (see [EXPL_ORB-SUM] for details), otherwise it is set to 27 blanks. It corresponds to the time after the Leap Second occurrence (i.e. midnight of the day after the leap second)	UTC	27	dd-MMM-yyyy hh:mm:ss.uuuuuu
	quotation mark (")		1	uc
	newline character	terminator	1	uc
#32	LEAP_SIGN=	Keyword	10	10*uc
	Leap second sign If a leap second occurred in the product window the field is set to the expected value by a devoted function in the CFI EXPLORER_ORBIT library (see [EXPL_ORB-SUM] for details), otherwise it is set to +000.	S	4	%+04d
	newline character	terminator	1	uc

Continued on next page

Field #	Description	Units	Bytes	Format
#33	LEAP_ERR=	keyword	9	9*uc
	Leap second error flag. This field is always set to 0 considering that CRYOSAT products have true UTC times.		1	uc
	newline character	terminator	1	uc
#34	Spare (blank characters)		40	40*uc
	newline character	terminator	1	uc
Product Confidence Data Information				
#35	PRODUCT_ERR=	keyword	12	12*uc
	Product Error Flag set to 1 if errors have been reported in the product		1	uc
	newline character	terminator	1	uc
Product Size Information				
#36	TOT_SIZE=	keyword	9	9*uc
	Total size of the product	bytes	21	%+021d
	<bytes>	units	7	7*uc
	newline character	terminator	1	uc
#37	SPH_SIZE=	keyword	9	9*uc
	Length of the SPH	bytes	11	%+011d
	<bytes>	units	7	7*uc
	newline character	terminator	1	uc
#38	NUM_DSD=	keyword	8	8*uc
	Number of Data Set Descriptors, including spares and all other types of DSDs		11	%+011d
	newline character	terminator	1	uc
#39	DSD_SIZE=	keyword	9	9*uc
	Length of each DSD	bytes	11	%+011d
	<bytes>	units	7	7*uc
	newline character	terminator	1	uc
#40	NUM_DATA_SETS=	keyword	14	14*uc
	Number of attached Data Sets (note that not all the DSDs have a DS attached)		11	%+011d
	newline character	terminator	1	uc
#41	CRC=	keyword	4	4*uc
	Cyclic Redundancy Code computed as overall value of all records of the Measurement Data Set. If not computed it shall be set to -00001		6	%+06d
	newline character	terminator	1	uc
#42	Spare (blank characters)		29	29*uc
	newline character	terminator	1	uc
Total				**1247**

Table 15: ASIRAS specific product header (SPH) format

Field #	Description	Units	Bytes	Format
Product description and identification				
#1	SPH_DESCRIPTOR=	keyword	15	15*uc
	quotation mark (")		1	uc
	ASCII string describing the product Set to ASI_SAR_1B SPECIFIC HEADER		28	28*uc
	quotation mark (")		1	uc
	newline character	terminator	1	uc
Product Time information				
#2	START_RECORD_TAI_TIME=	keyword	22	22*uc
	quotation mark (")		1	uc
	TAI of the first record in the Main MDS of this product	TAI	27	dd-MMM-yyyy hh:mm:ss.uuuuuu
	quotation mark (")		1	uc
	newline character	terminator	1	uc
#3	STOP_RECORD_TAI_TIME=	keyword	21	21*uc
	quotation mark (")		1	uc
	TAI of the last record in in the Main MDS of this product	TAI	27	dd-MMM-yyyy hh:mm:ss.uuuuuu
	quotation mark (")		1	uc
	newline character	terminator	1	uc
Product Orbit Information				
#4	ABS_ORBIT_START=	keyword	16	16*uc
	Absolute Orbit Number at Product Start Time		6	%06d
	newline character	terminator	1	uc
#5	REL_TIME_ASC_NODE_START=	Keyword	24	24*uc
	Relative time since crossing ascending node time relative to start time of data sensing	s	11	%011.6f
	<s>	units	3	3*uc
	newline character	terminator	1	uc
#6	ABS_ORBIT_STOP=	keyword	15	15*uc
	Absolute Orbit Number at Product Stop Time		6	%06d
	newline character	terminator	1	uc
#7	REL_TIME_ASC_NODE_STOP=	Keyword	23	23*uc
	Relative time since crossing ascending node time relative to stop time of data sensing	s	11	%011.6f
	<s>	units	3	3*uc
	newline character	terminator	1	uc

Continued on next page

Field #	Description	Units	Bytes	Format
#8	EQUATOR_CROSS_TIME_UTC=	Keyword	23	23*uc
	quotation mark (")		1	uc
	Time of Equator crossing at the ascending node of the sensing start time	UTC	27	dd-MMM-yyyy hh:mm:ss.uuuuuu
	quotation mark (")		1	uc
	newline character	terminator	1	uc
#9	EQUATOR_CROSS_LONG=	Keyword	19	19*uc
	Longitude of Equator Crossing at the ascending node of the sensing start time (positive East, 0 = Greenwich) referred to WGS84	s	11	%+011d
	<10-6degE>	units	10	10*uc
	newline character	terminator	1	uc
#10	ASCENDING_FLAG=	keyword	15	15*uc
	Orbit Orientation at the sensing start A= Ascending D= Descending		1	uc
	newline character	terminator	1	uc
Product Location Information				
#11	START_LAT=	keyword	10	10*uc
	WGS84 latitude of the first record in the Main MDS (positive north)	[10-6 deg]	11	%+011d
	<10-6degN>	units	10	10*uc
	newline character	terminator	1	uc
#12	START_LONG=	keyword	11	11*uc
	WGS84 longitude of the first record in the Main MDS (positive East, 0 = Greenwich)	[10-6 deg]	11	%+011d
	<10-6degE>	units	10	10*uc
	newline character	terminator	1	uc
#13	STOP_LAT=	keyword	9	9*uc
	WGS84 latitude of the last record in the Main MDS (positive north)	[10-6 deg]	11	%+011d
	<10-6degN>	units	10	10*uc
	newline character	terminator	1	uc
#14	STOP_LONG= keyword 10 10*uc			
	WGS84 longitude of the last record in the Main MDS (positive East, 0 = Greenwich)	[10-6 deg]	11	%+011d
	<10-6degE>	units	10	10*uc
	newline character	terminator	1	uc
#15	Spare (blank characters)		50	50*uc
	newline character	terminator	1	uc

Field #	Description	Units	Bytes	Format
Level 0 Quality information				
#16	L0_PROC_FLAG=	keyword	13	13*uc
	Processing errors significance flag (1 or 0). 1 if the percentage of SIRAL packets free of processing errors is less than the acceptable threshold		1	uc
	newline character	terminator	1	uc
#17	L0_PROCESSING_QUALITY=	keyword	22	22*uc
	Percentage of quality checks successfully passed during the SP processing (max allowed +10000)	[10-2%]	6	%+06d
	<10-2%>	units	7	7*uc
	newline character	terminator	1	uc
#18	L0_PROC_THRESH=	keyword	15	15*uc
	Minimum acceptable percentage of quality threshold that must be passed during SP processing (max allowed +10000)	[10-2%]	6	%+06d
	<10-2%>	units	7	7*uc
	newline character	terminator	1	uc
#19	L0_GAPS_FLAG=	keyword	13	13*uc
	Gaps significance flag (1 or 0). 1 if gaps (either caused by extraction or alignment failures) were detected during the SP processing		1	uc
	newline character	terminator	1	uc
#20	L0_GAPS_NUM=	keyword	12	12*uc
	Number of gaps detected during the SP processing (no gaps indicated as +0000000)		8	%+08d
	newline character	terminator	1	uc
#21	Spare (blank characters)	ascii	50	50*uc
	newline character	terminator	1	uc
ASIRAS Instrument Configuration				
#22	ASI_OP_MODE=	keyword	12	12*uc
	quotation mark (")		1	uc
	ASIRAS Operative Mode: HAM LAM (strings shorter than 10 are filled in with blanks)		10	10*uc
	quotation mark (")		1	uc
	newline character	terminator	1	uc

Field #	Description	Units	Bytes	Format
#23	ASI_CONFIGURATION=	keyword	18	17*uc
	quotation mark (")		1	uc
	SIRAL Configuration: RX_1 RX_2 BOTH UNKNOWN (strings shorter than 7 are filled in with blanks)		7	7*uc
	quotation mark (")		1	uc
	newline character	terminator	1	uc
Surface Statistics				
#24	OPEN_OCEAN_PERCENT=	keyword	19	19*uc
	Percentage of records detected on open ocean or semi-enclosed seas	[10-2%]	6	%+06d
	<10-2%>	units	7	7*uc
	newline character	terminator	1	uc
#25	CLOSE_SEA_PERCENT=	keyword	18	18*uc
	Percentage of records detected on seas or inland lakes	[10-2%]	6	%+06d
	<10-2%>	units	7	7*uc
	newline character	terminator	1	uc
#26	CONTINENT_ICE_PERCENT=	keyword	22	22*uc
	Percentage of records detected on continental ice	[10-2%]	6	%+06d
	<10-2%>	units	7	7*uc
	newline character	terminator	1	Uc
#27	LAND_PERCENT Keyword 13 13*uc			
	Percentage of records detected on land	[10-2%]	6	%+06d
	<10-2%>	units	7	7*uc
	newline character	terminator	1	uc
#28	Spare (blank characters)	ascii	50	50*uc
	newline character	terminator	1	uc
Level 1 Processing information				
#29	L1B_PROD_STATUS=	keyword	16	16*uc
	Complete/Incomplete Product Completion Flag (0 or 1). 1 if the Product as a duration shorter the input Level 0		1	uc
	newline character	terminator	1	uc
#30	L1B_PROC_FLAG=	keyword	14	14*uc
	Processing errors significance flag (1 or 1 if the percentage of DSR free of processing errors is less than the acceptable threshold		1	uc
	newline character	terminator	1	uc

Field #	Description	Units	Bytes	Format
#31	L1B_PROCESSING_QUALITY=	keyword	23	23*uc
	Percentage of quality checks successfully passed during Level 1B processing (max allowed +10000)	[10-2%]	6	%+06d
	<10-2%>	units	7	7*uc
	newline character	terminator	1	uc
#32	L1B_PROC_THRESH=	keyword	16	16*uc
	Minimum acceptable percentage of quality threshold that must be passed during Level 1B processing (max allowed +10000)	[10-2%]	6	%+06d
	<10-2%>	units	7	7*uc
	newline character	terminator	1	uc
#33	Spare (blank characters)	ascii	50	50*uc
	newline character	terminator	1	uc
Total				**1112**
		DSD Section		

Table 16: ASIRAS data set descriptors (DSD) format

Field #N	Description	Units	Bytes	Format
		DSD		
#N.1	DS_vvvvvvvvvvvvvvvv	keyword	8	8*uc
	quotation mark (")		1	uc
	Name describing the Data Set		28	28*uc
	quotation mark (")		1	uc
	newline character	terminator	1	uc
#N.2	DS_TYPE=	keyword	8	8*uc
	Type of Data Set. It can be: M = Measurement R = Reference		1	uc
	newline character	terminator	1	uc
	External Product Reference			
		External Product Reference		
#N.3	FILENAME=	keyword	9	9*uc
	quotation mark (")		1	uc
	Name of the Reference File. Used if DS_TYPE is set to R. It is left trailer blanks. The file name If not used it is set to 62 blanks.		62	62*uc
	quotation mark (")		1	uc
	newline character	terminator	1	uc
	Position and site of DS			

Field #N	Description	Units	Bytes	Format
Position and size of DS				
#N.4	DS_OFFSET=	keyword	10	10*uc
	Length in bytes of MPH + SPH DS size of previous Data Set (if	bytes	21	%+021d
	<bytes>	units	7	7*uc
	newline character	terminator	1	uc
#N.5	DS_SIZE=	keyword	8	8*uc
	Length in bytes of the attached Used if DS_TYPE is set to M If not used set to 0	bytes	21	%+021d
	<bytes>	units	7	7*uc
	newline character	terminator	1	uc
	Number and length of DSRs			
Number and length of DSRs				
#N.6	NUM_DSR=	keyword	8	8*uc
	Number of Data Set Records		11	%+011d
	newline character	terminator	1	uc
#N.7	DSR_SIZE=	keyword	9	9*uc
	Length in bytes of the Data Set If not used set to +0 If variable set to -1	bytes	11	%+011d
	<bytes>	units	7	7*uc
	newline character	terminator	1	uc
#N.8	Spare	ascii	32	32*uc
	newline character	terminator	1	uc
Total				**280**

The MDS can be further divided into five parts as described below:

1. Time and Orbit Group (20 blocks per record)
2. Measurements Group (20 blocks per record)
3. Corrections Group (one block per record)(Zeroed for ASIRAS)
4. Average waveforms Group (one block per record)(Zeroed for ASIRAS)
5. Waveform Group (20 blocks per record)

Table 17: ASIRAS measurement data set (MDS) format

Identifier	Description	Units	Type	Size [Bytes]
Time & Orbit Group Repeated 20 times				
1	Days	TAI	sl	4
2	Seconds		ul	4
3	Microseconds		ul	4
4	Spare		sl	4
5	Spare		us	2

Identifier	Description	Units	Type	Size [Bytes]
6	Spare		us	2
7	Instrument Config		ul	4
8	Burst Counter		ul	4
9	Geodetic latitude of	10^{-7} Deg	sl	4
10	Longitude of ASIRAS	10^{-7} Deg	sl	4
11	WGS-84 ellipsoidal	10^{-3} m	sl	4
12	Altitude rate determined	10^{-6} m/s	sl	4
13	Velocity [x,y,z], described	10^{-3} m/s	sl	3*4
14	Real antenna beam	10^{-6} m	sl	3*4
15	Interferometer baseline	10^{-6} m	sl	3*4
16	Measurement Confident		ul	4
Measurements Group Repeated 20 times				
17	Window delay	10-12 s	sll	8
18	Spare		sl	4
19	OCOG width	Range bins*100	sl	4
20	OCOG or threshold	10^{-3} m	sl	4
21	Surface elevation derived	10^{-3} m	sl	4
22	AGC Channel 1	dB/100	sl	4
23	AGC Channel 2	dB/100	sl	4
24	Total fixed gain Ch1	dB/100	sl	4
25	Total fixed gain Ch2	dB/100	sl	4
26	Transmit Power	10^{-6} Watts	sl	4
27	Doppler range correction	10^{-3} m	sl	4
28	Instrument range	10^{-3} m	sl	4
29	Instrument range	10^{-3} m	sl	4
30	Spare		sl	4
31	Spare		sl	4
32	Internal phase correction	10^{-6} rad	sl	4
33	External phase correction	10^{-6} rad	sl	4
34	Noise power	dB/100	sl	4
35	Roll	10^{-3} Deg	ss	2
36	Pitch	10^{-3} Deg	ss	2
37	Yaw	10^{-3} Deg	ss	2
38	Spare		ss	2
39	Heading	10^{-3} Deg	sl	4
40	Standard deviation of roll	10^{-4} Deg	us	2
41	Standard deviation of	10^{-4} Deg	us	2
42	Standard deviation of yaw	10^{-4} Deg	us	2
Corrections Group Once per record				
	Empty for ASIRAS			
43	Spare		uc	64*1
Average pulse-width limited Waveform group Once per record				
	Empty for ASIRAS			
44	Spare		uc	8236*1

Identifier	Description	Units	Type	Size [Bytes]
		Multilooked Waveform Group Repeated 20 times		
45	Multi-looked Power Echo.	Counts (0-65535)	us	4096*2
46	Linear scale factor, A		sl	4
47	Power of 2 scale factor,B		sl	4
48	Number of multilooked		us	2
49	Flags		us	2
50	Beam behaviour		us	50*2
Total				**177940**

7.2 GPS

Processed DGPS data is delivered in binary, big endian format with each record formated as described by Cullen (2010) and Table 20.

Table 18: GPS file format

Identifier	Description	Unit	Type	Size [Bytes]
1	Days (MJD)	UTC	sl	4
2	Seconds		ul	4
3	Microseconds		ul	4
4	Latitude	10^{-7} deg	sl	4
5	Longitude	10^{-7} deg	sl	4
6	Geodetic ellipsoidal height (WGS-84)	m	d	8
7	Spare_7	N/A	d	8
8	Spare_8	N/A	d	8
9	Spare_9	N/A	d	8
10	Spare_10	N/A	d	8
Total				**72**

7.3 INS

Processed INS data is delivered in binary, big endian format with each record formatted as described by Cullen (2010) and Table 21.

Table 19: INS file format

Identifier	Description	Unit	Type	Size [Bytes]
1	Days (MJD)	UTC	sl	4
2	Seconds		sl	4
3	Microseconds		sl	4
4	Latitude (WGS-84)	Deg	d	8
5	Longitude	Deg	d	8
6	Ground speed	Kts	d	8
7	True Track	Deg	d	8
8	True Heading	Deg	d	8
9	Wind Speed	Kts	d	8
10	Wind Direction	Deg	d	8
11	Magnetic Heading	Deg	d	8
12	Pitch	Deg	d	8
13	Roll	Deg	d	8
14	Pitch Rate	deg/s	d	8
15	Roll Rate	deg/s	d	8
16	Yaw Rate	deg/s	d	8
17	Body longitudinal	G	d	8
18	Body lateral Acceleration	G	d	8
19	Body normal acceleration	G	d	8
20	Vertical Acceleration in G	G	d	8
21	Velocity Inertial Vertical	ft/min	d	8
22	Velocity North-South	Kts	d	8
23	Velocity East-west	Kts	d	8
Total				**172**

7.4 Laser scanner (ALS)

Processed ALS data is delivered in binary, little endian format with each record formatted as described in Table 22. Note that time is in decimal hours since the beginning of the day with respect to UTC time.

Table 20: INS file format

Identifier	Description	Unit	Type	Size [Bytes]
Header				
1	Header Size	bytes	uc	1
2	Number of scan lines, N_{als_scan}	lines	ul	4
3	Number of data points per line, N_{als_dppl}	points	uc	1
4	Bytes per line, N_{als_bbl}	bytes	us	2
5	Bytes sec line	bytes	ull	8
6	Year of acquisition	UTC	us	2
7	Month of acquisition	UTC	uc	1
8	Day of acquisition	UTC	uc	1
9	Acquisition Start time (Seconds of day)	UTC	ul	4
10	Acquisition Stop time (Seconds of day)	UTC	ul	4
11	Device name		uc	8
Total				**36**
Time stamp array				
1	Array of time stamps for each scan line	UTC	ul	$4*N_{als\_scan}$
Total				$\mathbf{4*N_{als\_scan}}$
DEM Record Repeated N_{als_scan} times				
1	Array of time stamps for each point	UTC	d	$8*N_{als\_dppl}$
2	Array of latitudes for each point	degrees	d	$8*N_{als\_dppl}$
3	Array of longitudes for each point	degrees	d	$8*N_{als\_dppl}$
2	Array of ellipsoidal heights for each point	meter	d	$8*N_{als\_dppl}$
Total				$\mathbf{N_{als\_bbl}}$

7.5 Electromagnetic sounding (AEM)

The format of the EM datafiles (blank separated ASCII data) is given in table 23. All time tags are standard UTC time.

Table 21: EM data file format

Column	Description	Unit
1	Year	-
2	Month	-
3	Day	-
4	Second of the Day	-
5	Fiducial Number	-
6	Latitude	Deg
7	Longitude	Deg
8	Distance	m
9	Total Thickness	m
10	Laser Range	m

7.6 Vertical Camera

Approximate time and position of the vertical camera when a picture is taken is delivered in windows ASCII format as described in Table 24 and all individual pictures are in JPEG format. Each ASCII line gives the filename, time and position for the named picture. If no DGPS data is available the time and position is replaced with the string “No position available”.

Table 22: Position file format for vertical images

Identifier	Description	Unit
1	JPEG filename	
2	Decimal hours	hour
3	Latitude (WGS-84)	deg
4	Longitude	deg
5	Geodetic ellipsoidal height	m
6	Newline characters "\r \n"	

8 APPENDIX Processed GPS data in ESA format

Date	Filename	Start time (Sec of day)	Stop time (Sec of day)	File size
26-03-2012	GPS_F_20120326T110842_133236_0001	40122	48756	0.5
26-03-2012	GPS_R_20120326T135657_170331_0001	50217	61411	0.7
27-03-2012	GPS_F_20120327T104925_160144_0001	38965	57704	1.1
28-03-2012	GPS_R_20120328T124450_164526_0001	45890	60326	0.8
29-03-2012	GPS_F_20120329T120136_170503_0001	43296	61503	1.1
30-03-2012	GPS_F_20120330T113826_145808_0001	41906	53888	0.7
30-03-2012	GPS_F_20120330T153445_192204_0001	56085	69724	0.8
02-04-2012	GPS_R_20120402T114419_173226_0001	42259	63146	1.2
03-04-2012	GPS_R_20120403T134219_183739_0001	49339	67059	1.0
04-04-2012	GPS_F_20120404T152059_195343_0001	55259	71623	1.0
05-04-2012	GPS_R_20120405T150345_205411_0001	54225	75251	1.2
06-04-2012	GPS_F_20120406T142344_164709_0001	51824	60429	0.5
06-04-2012	GPS_R_20120406T171535_214118_0001	62135	78078	0.9
24-04-2012	GPS_R_20120424T094554_124801_0001	35154	46081	0.6
24-04-2012	GPS_R_20120424T130612_174856_0001	47172	64136	1.0
25-04-2012	GPS_F_20120425T144041_175250_0001	52841	64370	0.7
25-04-2012	GPS_F_20120425T182131_222727_0001	66091	80847	0.9
27-04-2012	GPS_R_20120427T145451_191939_0001	53691	69579	0.9
28-04-2012	GPS_F_20120428T085330_134618_0001	32010	49578	1.0
29-04-2012	GPS_R_20120429T091342_141340_0001	33222	51220	1.1
29-04-2012	GPS_R_20120429T152516_205325_0001	55513	75205	1.2
01-05-2012	GPS_R_20120501T115916_173841_0001	43153	63521	1.2
03-05-2012	GPS_R_20120503T113855_184634_0001	41935	67594	1.5
04-05-2012	GPS_R_20120504T125317_174849_0001	46397	64129	1.0
05-05-2012	GPS_F_20120505T110920_161259_0001	40160	58379	1.1

9 APPENDIX Processed INS data in ESA format

Date	Filename	Start time (Sec of day)	Stop time (Sec of day)	File size (Mb)
26-03-2012	INS_20120326T112100_132933_0001	406320	48573	13.0
26-03-2012	INS_20120326T140000_170029_0001	50400	61229	18.2
27-03-2012	INS_20120327T110000_160001_0001	39600	57601	30.2
28-03-2012	INS_20120328T130000_164452_0001	46800	60292	22.7
29-03-2012	INS_20120329T120300_170110_0001	43380	61270	30.1
30-03-2012	INS_20120330T120000_145333_0001	43200	53613	17.5
30-03-2012	INS_20120330T153600_191913_0001	56160	69553	22.5
02-04-2012	INS_20120402T112839_173131_0001	41319	63091	36.6
03-04-2012	INS_20120403T140000_183558_0001	50400	66958	27.8
04-04-2012	INS_20120404T151830_194936_0001	55110	71376	27.3
05-04-2012	INS_20120405T150418_205316_0001	54258	75196	35.2
06-04-2012	INS_20120406T145758_164411_0001	53878	60251	10.7
06-04-2012	INS_20120406T171455_213914_0001	62095	77954	26.6
24-04-2012	INS_20120424T101800_124147_0001	37080	45707	14.5
24-04-2012	INS_20120424T131200_174501_0001	47520	63901	27.5
25-04-2012	INS_20120425T144800_175101_0001	53280	64261	18.4
25-04-2012	INS_20120425T182700_222213_0001	66420	80533	23.7
27-04-2012	INS_20120427T145436_191409_0001	53676	69249	26.2
28-04-2012	INS_20120428T090900_134156_0001	32940	49316	27.5
29-04-2012	INS_20120429T104424_140824_0001	38664	50904	20.6
29-04-2012	INS_20120429T153900_205101_0001	56340	75061	31.4
01-05-2012	INS_20120501T120448_172325_0001	43488	62605	32.1
03-05-2012	INS_20120503T134200_183413_0001	49320	66853	29.5
04-05-2012	INS_20120504T130600_174501_0001	47160	63901	28.1
05-05-2012	INS_20120505T113000_160901_0001	41400	58141	28.1

10 APPENDIX Processed ALS data in ESA format

Date	Filename	Start time (Sec of day)	Stop time (Sec of day)	File size (MB)
2012-03-29	ALS_L1B_20120329T130356_135901	47036	50341	1071.7
2012-03-29	ALS_L1B_20120329T140730_151316	50850	54796	1279.6
2012-03-29	ALS_L1B_20120329T151400_161717	54840	58637	1231.3
2012-03-29	ALS_L1B_20120329T161800_165359	58680	60839	700.3
2012-03-29	ALS_L1B_20120329T165418_165453	60858	60893	11.7
2012-03-30	ALS_L1B_20120330T130500_140647	47100	50807	1200.8
2012-03-30	ALS_L1B_20120330T140830_143008	50910	52208	420.8
2012-03-30	ALS_L1B_20120330T143230_145228	52350	53548	388.4
2012-03-30	ALS_L1B_20120330T163900_172714	59940	62834	938.4
2012-03-30	ALS_L1B_20120330T172800_183225	62880	66745	1253.3
2012-04-02	ALS_L1B_20120402T122233_131826	44553	47906	1052.8
2012-04-02	ALS_L1B_20120402T131900_141514	47940	51314	1093.9
2012-04-02	ALS_L1B_20120402T142526_150711	51926	54431	812.2
2012-04-02	ALS_L1B_20120402T150800_160743	54480	58063	1161.9
2012-04-02	ALS_L1B_20120402T160830_170155	58110	61315	1039.2
2012-04-02	ALS_L1B_20120402T170300_171647	61380	62207	268.4
2012-04-02	ALS_L1B_20120402T172024_172100	62424	62460	11.7
2012-04-03	ALS_L1B_20120403T140401_145959	50641	53999	1003.7
2012-04-03	ALS_L1B_20120403T150030_155938	54030	57578	1150.7
2012-04-03	ALS_L1B_20120403T160030_165838	57630	61118	1131.1
2012-04-03	ALS_L1B_20120403T165900_180155	61140	64915	1224.0
2012-04-03	ALS_L1B_20120403T180300_181629	64980	65789	262.5
2012-04-04	ALS_L1B_20120404T160600_171038	57960	61838	1257.8
2012-04-04	ALS_L1B_20120404T171100_175745	61860	64665	848.0
2012-04-04	ALS_L1B_20120404T180400_185847	65040	68327	1064.5
2012-04-04	ALS_L1B_20120404T185930_192743	68370	70063	549.0
2012-04-05	ALS_L1B_20120405T155000_163935	57000	59975	947.8
2012-04-05	ALS_L1B_20120405T171030_180446	61830	65086	927.9
2012-04-05	ALS_L1B_20120405T180530_185959	65130	68399	1060.3
2012-04-05	ALS_L1B_20120405T190030_191951	68430	69591	376.6
2012-04-06	ALS_L1B_20120406T180100_185817	64860	68297	1114.9
2012-04-06	ALS_L1B_20120406T185900_195828	68340	71908	1157.4
2012-04-06	ALS_L1B_20120406T195930_205655	71970	75415	1115.4
2012-04-24	ALS_L1B_20120424T131902_140819	47942	50899	750.9
2012-04-24	ALS_L1B_20120424T140859_150650	50939	54410	1125.1
2012-04-24	ALS_L1B_20120424T150730_160815	54450	58095	1182.2
2012-04-24	ALS_L1B_20120424T160900_164540	58140	60340	694.7

Continued on next page

Date	Filename	Start time (Sec of day)	Stop time (Sec of day)	File size (MB)
2012-04-27	ALS_L1B_20120427T153400_161924	56040	58764	825.2
2012-04-27	ALS_L1B_20120427T161959_170613	58799	61573	898.8
2012-04-27	ALS_L1B_20120427T170700_181003	61620	65403	1198.6
2012-04-27	ALS_L1B_20120427T190148_190233	68508	68553	14.7
2012-04-27	ALS_L1B_20120427T190913_191002	68953	69002	16.0
2012-04-28	ALS_L1B_20120428T100000_102435	36000	37475	478.7
2012-04-28	ALS_L1B_20120428T103336_105501	38016	39301	355.1
2012-04-28	ALS_L1B_20120428T110300_112323	39780	41003	372.0
2012-04-28	ALS_L1B_20120428T112924_115101	41364	42661	395.0
2012-04-29	ALS_L1B_20120429T105130_111952	39090	40792	328.5
2012-04-29	ALS_L1B_20120429T134613_134641	49573	49601	9.2
2012-04-29	ALS_L1B_20120429T135328_135354	50008	50034	8.7
2012-04-29	ALS_L1B_20120429T155848_162206	57528	58926	453.5
2012-04-29	ALS_L1B_20120429T162230_171719	58950	62239	1060.6
2012-04-29	ALS_L1B_20120429T171800_180538	62280	65138	921.2
2012-04-29	ALS_L1B_20120429T180630_190452	65190	68692	1128.6
2012-04-29	ALS_L1B_20120429T190530_200138	68730	72098	1092.2
2012-04-29	ALS_L1B_20120429T200206_203935	72126	74375	729.5
2012-05-01	ALS_L1B_20120501T123230_131528	45150	47728	836.0
2012-05-01	ALS_L1B_20120501T131600_132345	47760	48225	150.5
2012-05-01	ALS_L1B_20120501T131600_140836	47760	50916	1023.7
2012-05-01	ALS_L1B_20120501T140900_150934	50940	54574	1178.5
2012-05-01	ALS_L1B_20120501T151000_160411	54600	57851	1054.5
2012-05-01	ALS_L1B_20120501T160430_170708	57870	61628	1218.8
2012-05-03	ALS_L1B_20120503T151230_160555	54750	57955	971.0
2012-05-03	ALS_L1B_20120503T160630_170001	57990	61201	1041.4
2012-05-03	ALS_L1B_20120503T170030_172048	61230	62448	336.1
2012-05-05	ALS_L1B_20120505T113300_124234	41580	45754	1250.7
2012-05-05	ALS_L1B_20120505T124300_134108	45780	49268	1130.5
2012-05-05	ALS_L1B_20120505T155718_155829	57438	57509	23.4

11 APPENDIX Time-tagged and geo-located images

	Date of acquisition	File name of zipped images	File size (MB)
089A_jpeg.pos	29-03-2012	20120329-125208.zip	629
		20120329-130000.zip	5,269
		20120329-140000.zip	4,244
		20120329-150000.zip	2,321
089B_jpeg.pos	29-03-2012	20120329-154057.zip	1,932
		20120329-160000.zip	5,735
090A_jpeg.pos	30-03-2012	20120330-121412.zip	2,072
		20120330-130000.zip	3,228
		20120330-140000.zip	2,554
090B_jpeg.pos	30-03-2012	20120330-155242.zip	313
		20120330-160000.zip	3,230
		20120330-170000.zip	2,418
		20120330-180000.zip	2,317
		20120330-190000.zip	1,611
093_jpeg.pos	02-04-2012	20120402-122600.zip	920
		20120402-130000.zip	2,435
		20120402-140000.zip	2,168
		20120402-150000.zip	2,488
		20120402-160000.zip	2,297
		20120402-170000.zip	1,313
094_jpeg.pos	03-04-2012	20120403-141113.zip	1,705
		20120403-150000.zip	2,037
		20120403-160000.zip	2,502
		20120403-170000.zip	2,125
		20120403-180000.zip	1,302
095_jpeg.pos	04-04-2012	20120404-155020.zip	138
		20120404-160000.zip	2,849
		20120404-170000.zip	2,690
		20120404-180000.zip	2,733
		20120404-190000.zip	2,458
096_jpeg.pos	05-04-2012	20120405-153900.zip	858
		20120405-160000.zip	1,782
		20120405-170000.zip	2,102
		20120405-180000.zip	2,253
		20120405-190000.zip	2,160
		20120405-200000.zip	2,464
118_jpeg.pos	27-04-2012	20120427-170000.zip	2.788
		20120427-145436.zip	404
		20120427-160000.zip	2.601
		20120427-150000.zip	2.303

Continued on next page

ASCII file	Date of acquisition	File name of zipped images	File size (MB)
119_jpeg.pos	28-04-2012	20120428-091306.zip	1,636
		20120428-100000.zip	1,957
		20120428-110000.zip	2,458
		20120428-120000.zip	1,920
120A_jpeg.pos	29-04-2012	20120429-104928.zip	359
		20120429-110000.zip	2,014
		20120429-120000.zip	2,167
		20120429-130000.zip	2,283
		20120429-140000.zip	405
120B_jpeg.pos	29-04-2012	20120429-153038.zip	1,112
		20120429-160000.zip	2,616
		20120429-170000.zip	1,859
		20120429-180000.zip	2,026
		20120429-190000.zip	2,133
		20120429-200000.zip	2,571
122_jpeg.pos	01-05-2012	20120501-120000.zip	2,313
		20120501-130000.zip	3,335
		20120501-140000.zip	2,463
124_jpeg.pos	03-05-2012	20120503-150000.zip	2,903
		20120503-160000.zip	2,480
		20120503-170000.zip	1,028
		20120503-143848.zip	939

12 APPENDIX Processed ASIRAS profiles

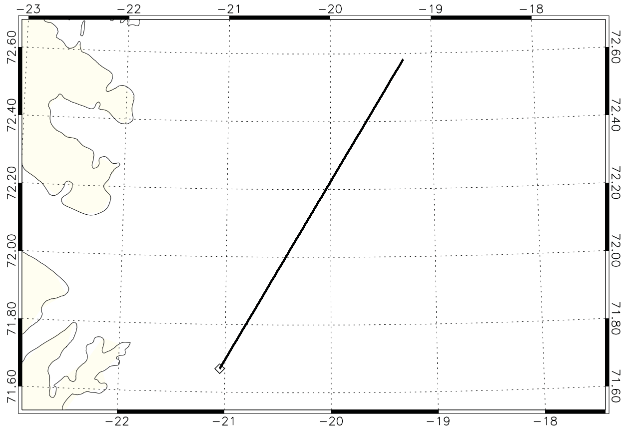
Following plots show all processed ASIRAS profiles. Each profile plot consists of four parts:

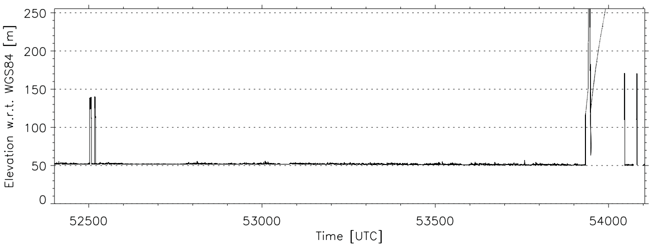
1. Header composed of daily profile number and the date and a sub-header with the filename.
2. Geographical plot of the profile (diamond indicates the start of the profile).
3. Rough indication of the heights as determined with the OCOG retracker plotted versus time of day in seconds.
4. Info box with date, start and stop times in hour, minute, seconds, and in square brackets seconds of the day, acquisition mode etc.

It should be emphasized that the surface height determined by the OCOG retracker is a rough estimate and not a true height.

A120326_00

AS30A00_ASIWL1B040320120326T143322_20120326T150146_0001.DBL

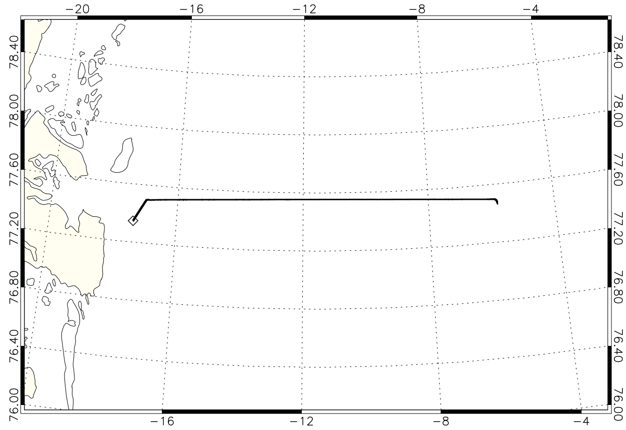


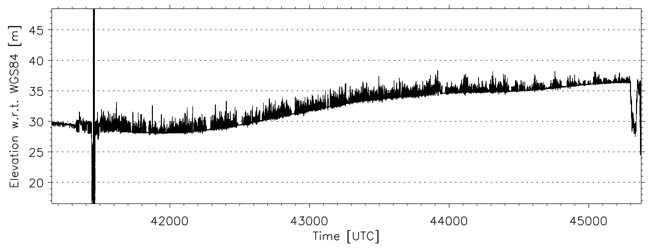


Date	2012-03-26	**Instrument Mode**	Adv. Low Altitude
Start Time	14:33:21 (52401)	**Aircraft**	DNSC Twin Otter
Stop Time	15:01:44 (54104)	**Retracker**	OCOG
Distance	118.271 km	**INS Resolution**	50 Hz
Duration	00 h 28 m 24 s	**Processor Version**	0403

A120327_00

AS30A00_ASIWL1B040320120327T112554_20120327T123616_0001.DBL

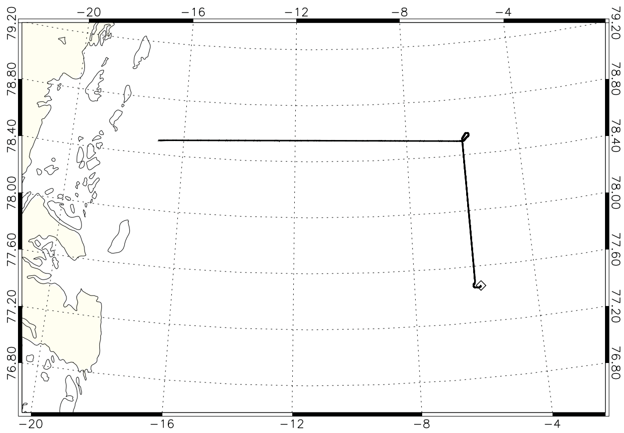


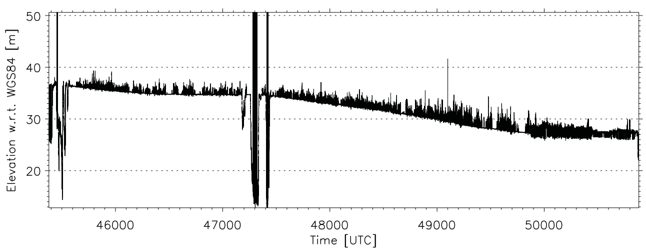


Date	2012-03-27	**Instrument Mode**	Adv. Low Altitude
Start Time	11:25:54 (41154)	**Aircraft**	DNSC Twin Otter
Stop Time	12:36:15 (45375)	**Retracker**	OCOG
Distance	290.342 km	**INS Resolution**	50 Hz
Duration	01 h 10 m 22 s	**Processor Version**	0403

A120327_01

AS30A01_ASIWL1B040320120327T123619_20120327T140803_0001.DBL

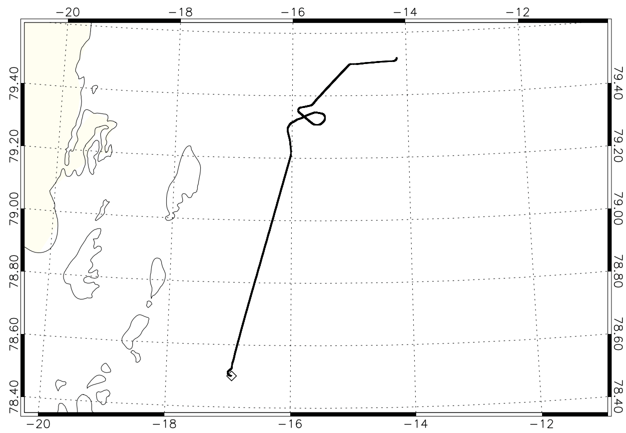


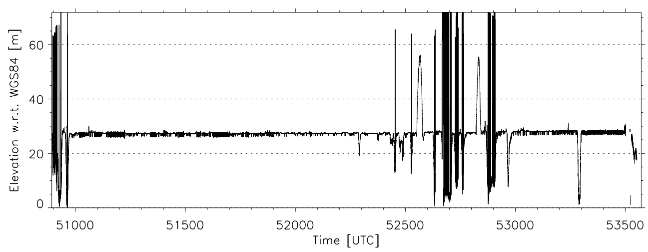


Date	2012-03-27	**Instrument Mode**	Adv. Low Altitude
Start Time	12:36:19 (45379)	**Aircraft**	DNSC Twin Otter
Stop Time	14:08:02 (50882)	**Retracker**	OCOG
Distance	382.797 km	**INS Resolution**	50 Hz
Duration	01 h 31 m 44 s	**Processor Version**	0403

A120327_02

AS30A02_ASIWL1B040320120327T140813_20120327T145252_0001.DBL

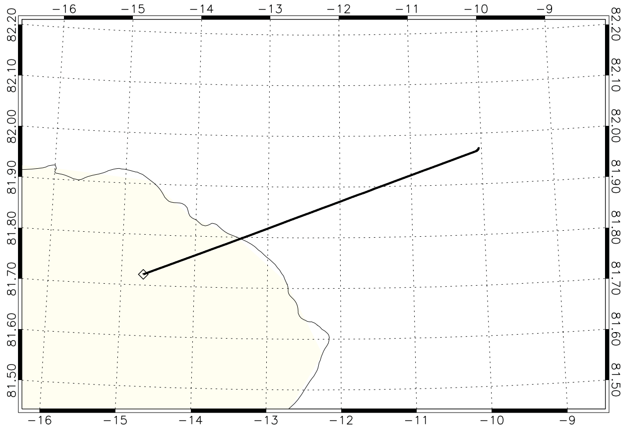


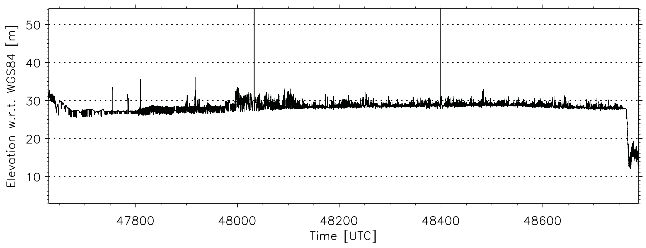


Date	2012-03-27	**Instrument Mode**	Adv. Low Altitude
Start Time	14:08:13 (50893)	**Aircraft**	DNSC Twin Otter
Stop Time	14:52:51 (53571)	**Retracker**	OCOG
Distance	164.620 km	**INS Resolution**	50 Hz
Duration	00 h 44 m 39 s	**Processor Version**	0403

A120328_00

AS30A00_ASIWL1B040320120328T131349_20120328T133309_0001.DBL

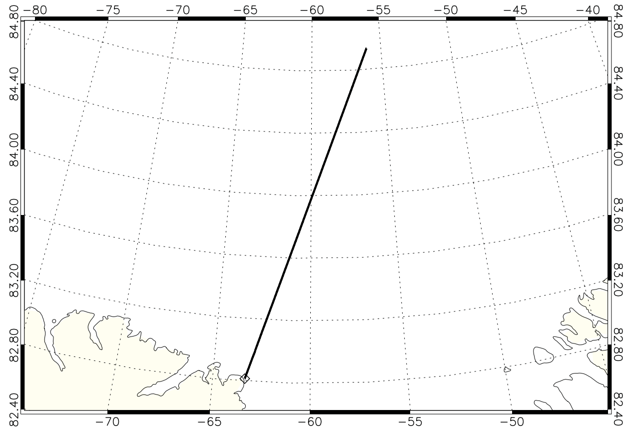


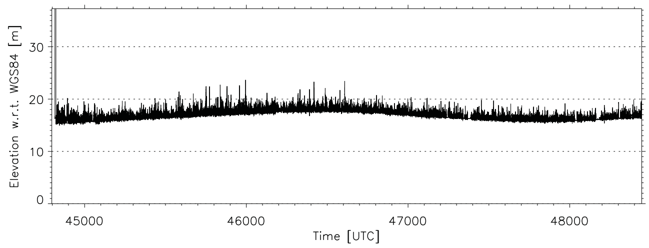


Date	2012-03-28	**Instrument Mode**	Adv. Low Altitude
Start Time	13:13:49 (47629)	**Aircraft**	DNSC Twin Otter
Stop Time	13:33:08 (48788)	**Retracker**	OCOG
Distance	79.001 km	**INS Resolution**	50 Hz
Duration	00 h 19 m 19 s	**Processor Version**	0403

A120329_00

AS30A00_ASIWL1B040320120329T122637_20120329T132725_0001.DBL

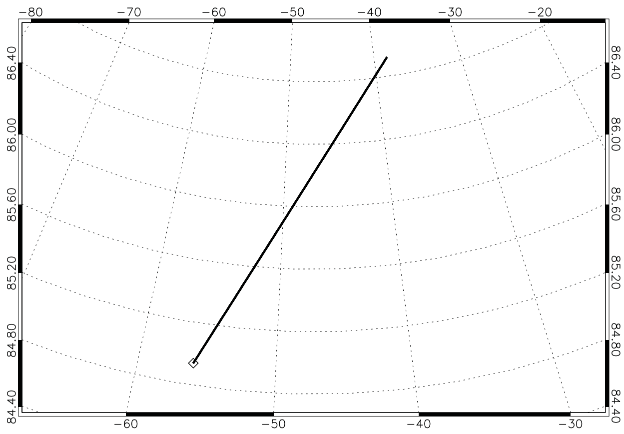


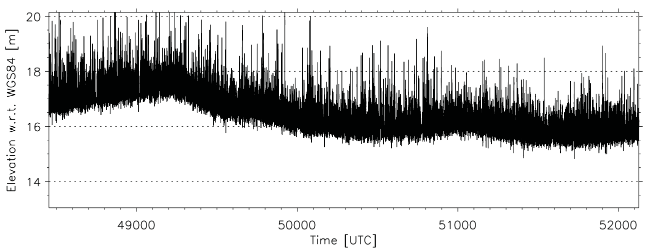


Date	2012-03-29	**Instrument Mode**	Adv. Low Altitude
Start Time	12:26:37 (44797)	**Aircraft**	DNSC Twin Otter
Stop Time	13:27:24 (48444)	**Retracker**	OCOG
Distance	250.391 km	**INS Resolution**	50 Hz
Duration	01 h 00 m 48 s	**Processor Version**	0403

A120329_01

AS30A01_ASIWL1B040320120329T132734_20120329T142847_0001.DBL

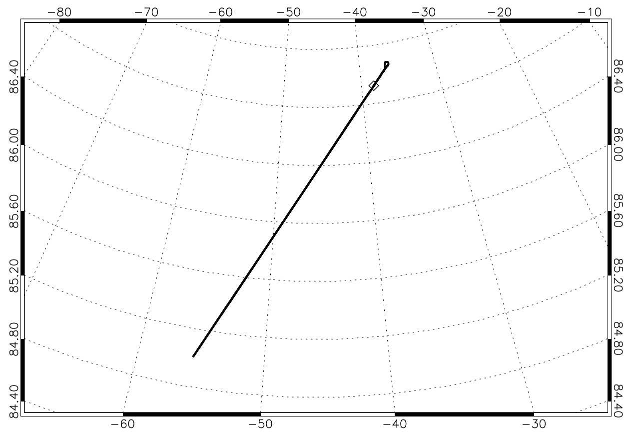


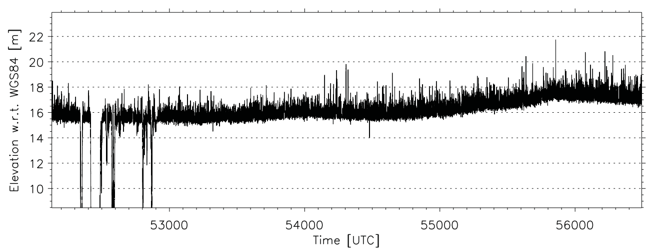


Date	2012-03-29	**Instrument Mode**	Adv. Low Altitude
Start Time	13:27:34 (48454)	**Aircraft**	DNSC Twin Otter
Stop Time	14:28:46 (52126)	**Retracker**	OCOG
Distance	257.498 km	**INS Resolution**	50 Hz
Duration	01 h 01 m 12 s	**Processor Version**	0403

A120329_02

AS30A02_ASIWL1B040320120329T142850_20120329T154133_0001.DBL

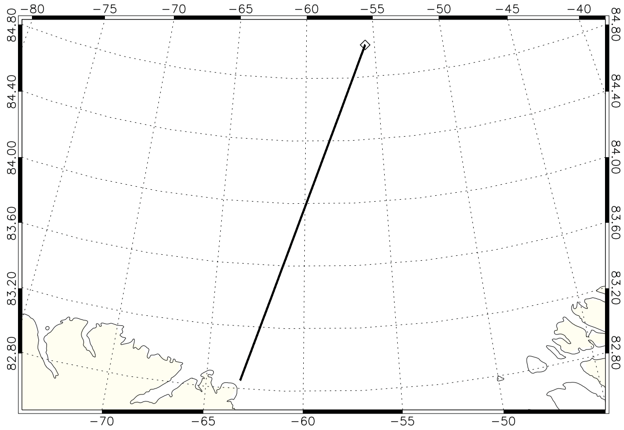


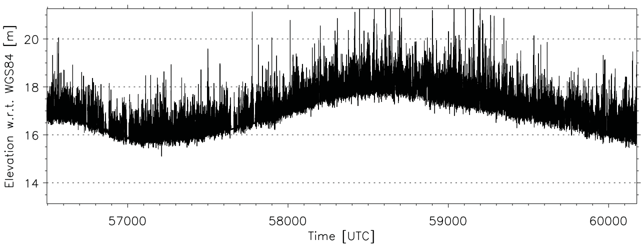


Date	2012-03-29	**Instrument Mode**	Adv. Low Altitude
Start Time	14:28:50 (52130)	**Aircraft**	DNSC Twin Otter
Stop Time	15:41:32 (56492)	**Retracker**	OCOG
Distance	293.661 km	**INS Resolution**	50 Hz
Duration	01 h 12 m 43 s	**Processor Version**	0403

A120329_03

AS30A03_ASIWL1B040320120329T154136_20120329T164256_0001.DBL

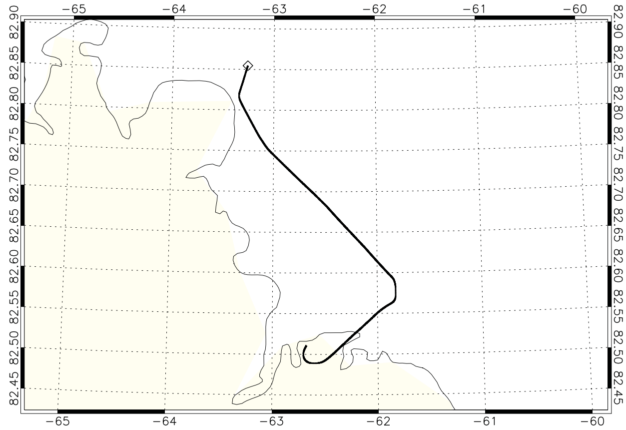


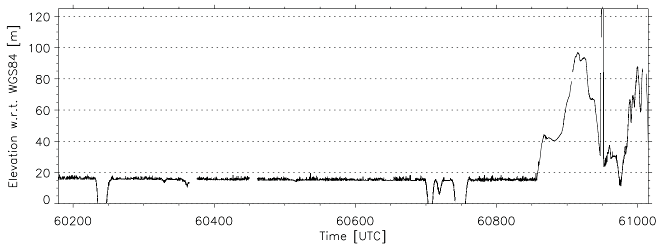


Date	2012-03-29	**Instrument Mode**	Adv. Low Altitude
Start Time	15:41:36 (56496)	**Aircraft**	DNSC Twin Otter
Stop Time	16:42:55 (60175)	**Retracker**	OCOG
Distance	254.369 km	**INS Resolution**	50 Hz
Duration	01 h 01 m 20 s	**Processor Version**	0403

A120329_04

AS30A04_ASIWL1B040320120329T164259_20120329T165655_0001.DBL

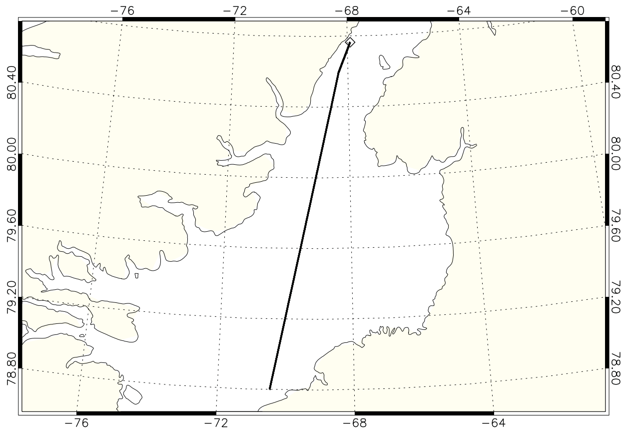


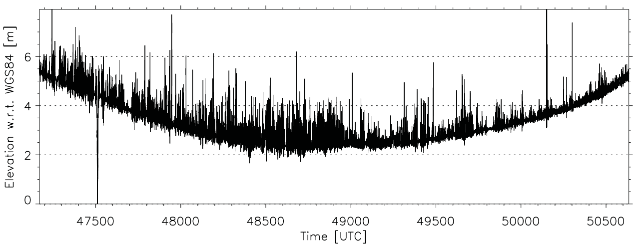


Date	2012-03-29	**Instrument Mode**	Adv. Low Altitude
Start Time	16:42:59 (60179)	**Aircraft**	DNSC Twin Otter
Stop Time	16:56:54 (61014)	**Retracker**	OCOG
Distance	57.977 km	**INS Resolution**	50 Hz
Duration	00 h 13 m 56 s	**Processor Version**	0403

A120330_00

AS30A00_ASIWL1B040320120330T130609_20120330T140354_0001.DBL

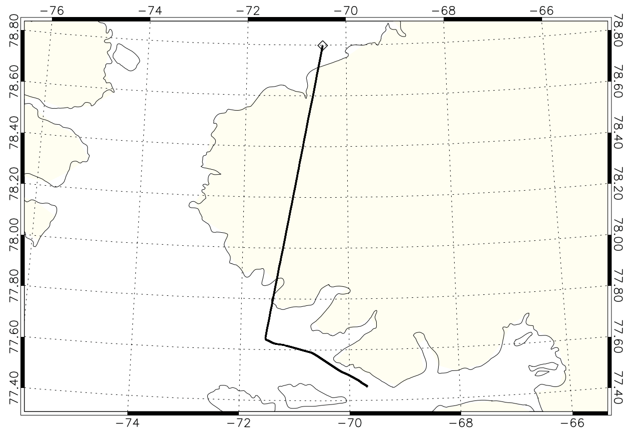


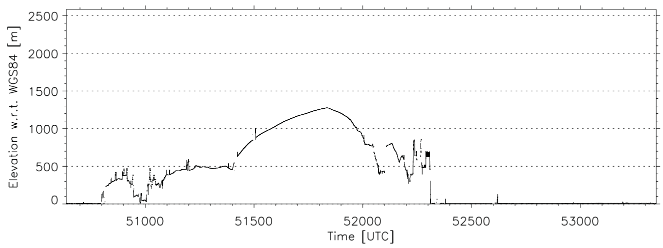


Date	2012-03-30	**Instrument Mode**	Adv. Low Altitude
Start Time	13:06:09 (47169)	**Aircraft**	DNSC Twin Otter
Stop Time	14:03:53 (50633)	**Retracker**	OCOG
Distance	224.065 km	**INS Resolution**	50 Hz
Duration	00 h 57 m 45 s	**Processor Version**	0403

A120330_01

AS30A01_ASIWL1B040320120330T140357_20120330T144909_0001.DBL

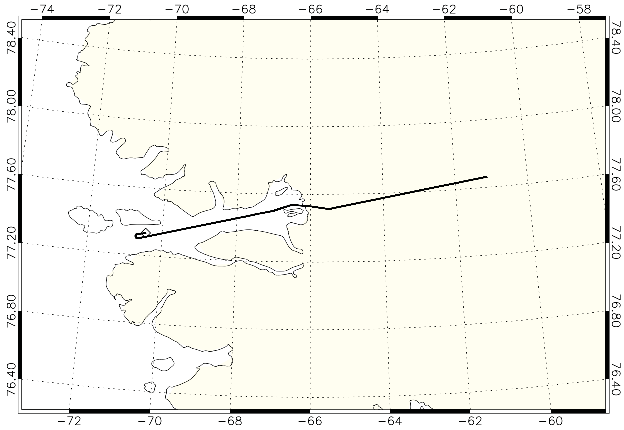


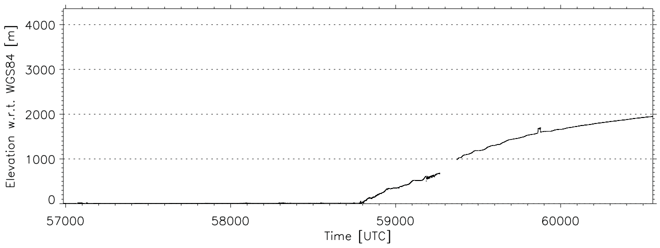


Date	2012-03-30	**Instrument Mode**	Adv. Low Altitude
Start Time	14:03:57 (50637)	**Aircraft**	DNSC Twin Otter
Stop Time	14:49:08 (53348)	**Retracker**	OCOG
Distance	181.147 km	**INS Resolution**	50 Hz
Duration	00 h 45 m 12 s	**Processor Version**	0403

A120330_02

AS30A02_ASIWL1B040320120330T154946_20120330T164919_0001.DBL

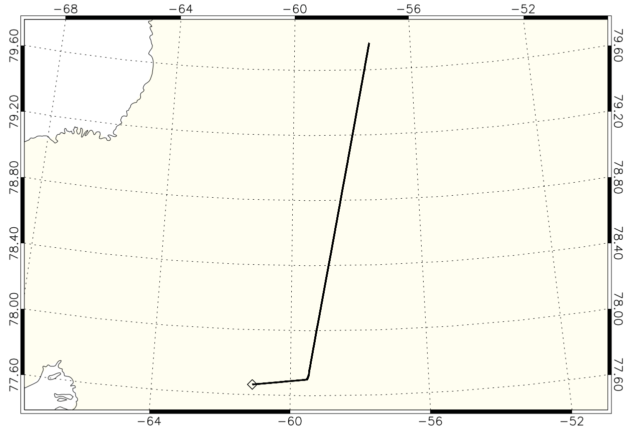


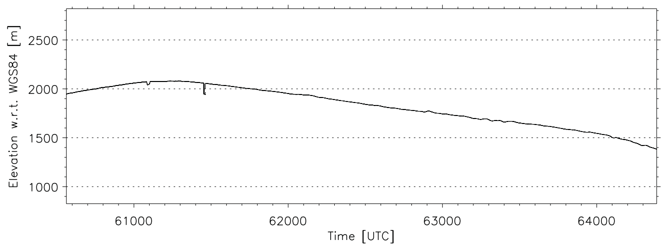


Date	2012-03-30	**Instrument Mode**	Adv. Low Altitude
Start Time	15:49:46 (56986)	**Aircraft**	DNSC Twin Otter
Stop Time	16:49:18 (60558)	**Retracker**	OCOG
Distance	243.970 km	**INS Resolution**	50 Hz
Duration	00 h 59 m 33 s	**Processor Version**	0403

A120330_03

AS30A03_ASIWL1B040320120330T164922_20120330T175309_0001.DBL

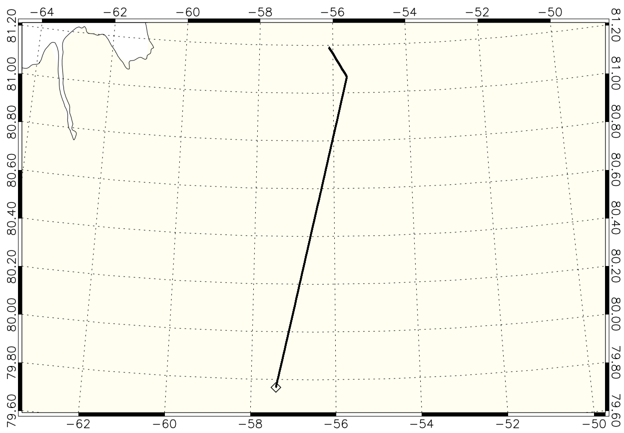


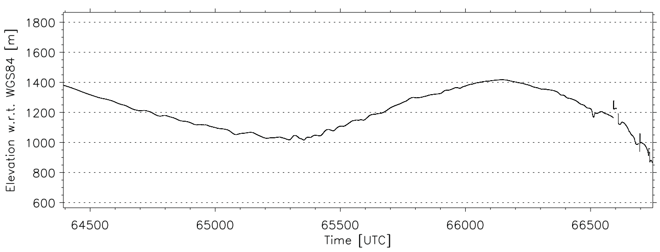


Date	2012-03-30	**Instrument Mode**	Adv. Low Altitude
Start Time	16:49:22 (60562)	**Aircraft**	DNSC Twin Otter
Stop Time	17:53:08 (64388)	**Retracker**	OCOG
Distance	272.002 km	**INS Resolution**	50 Hz
Duration	01 h 03 m 47 s	**Processor Version**	0403

A120330_04

AS30A04_ASIWL1B040320120330T175313_20120330T183229_0001.DBL

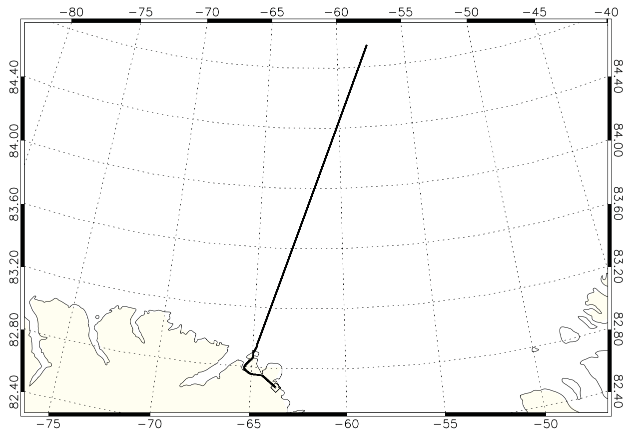


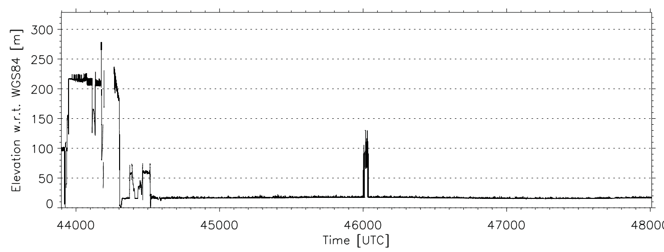


Date	2012-03-30	**Instrument Mode**	Adv. Low Altitude
Start Time	17:53:13 (64393)	**Aircraft**	DNSC Twin Otter
Stop Time	18:32:28 (66748)	**Retracker**	OCOG
Distance	164.100 km	**INS Resolution**	50 Hz
Duration	00 h 39 m 16 s	**Processor Version**	0403

A120402_00

AS30A00_ASIWL1B040320120402T121138_20120402T132010_0001.DBL

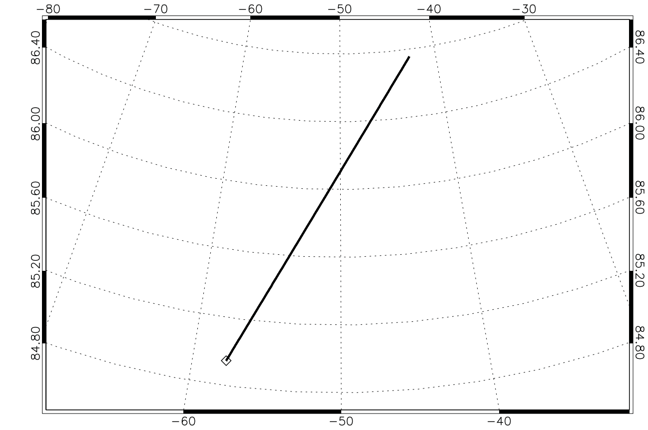


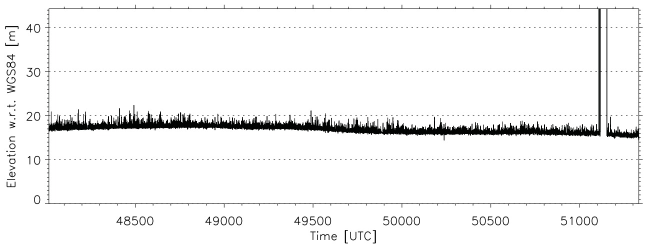


Date	2012-04-02	**Instrument Mode**	Adv. Low Altitude
Start Time	12:11:38 (43898)	**Aircraft**	DNSC Twin Otter
Stop Time	13:20:10 (48010)	**Retracker**	OCOG
Distance	284.744 km	**INS Resolution**	50 Hz
Duration	01 h 08 m 32 s	**Processor Version**	0403

A120402_01

AS30A01_ASIWL1B040320120402T132014_20120402T141533_0001.DBL

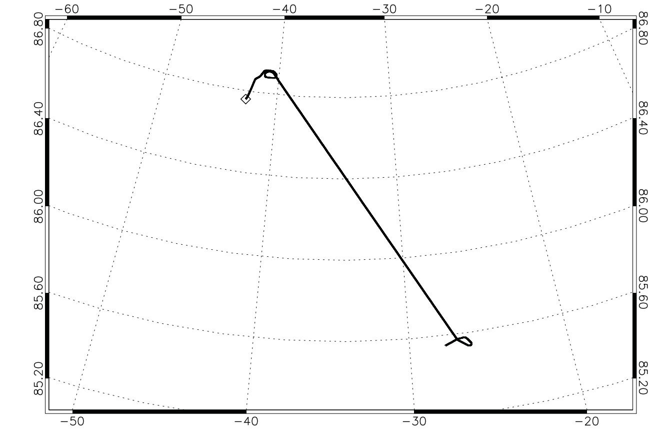


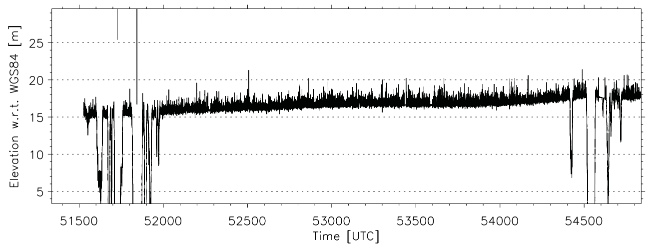


Date	2012-04-02	**Instrument Mode**	Adv. Low Altitude
Start Time	13:20:14 (48014)	**Aircraft**	DNSC Twin Otter
Stop Time	14:15:32 (51332)	**Retracker**	OCOG
Distance	232.771 km	**INS Resolution**	50 Hz
Duration	00 h 55 m 19 s	**Processor Version**	0403

A120402_02

AS30A02_ASIWL1B040320120402T141537_20120402T151359_0001.DBL

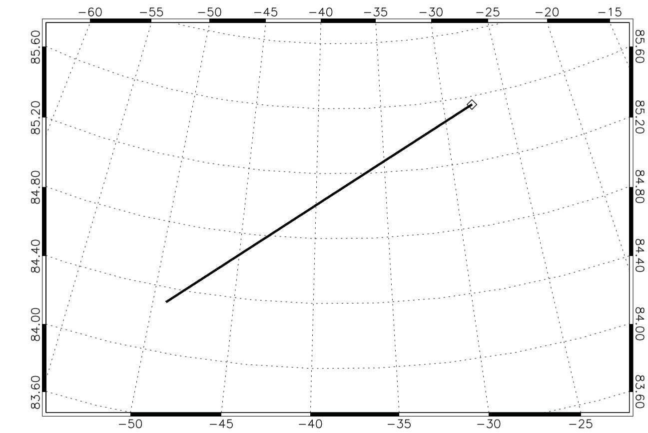


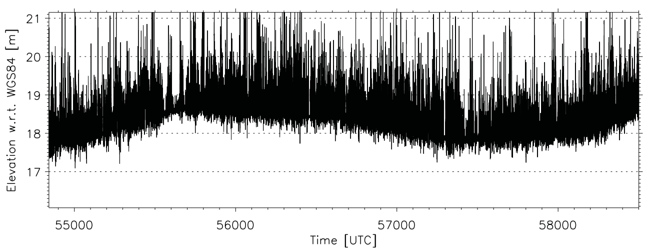


Date	2012-04-02	**Instrument Mode**	Adv. Low Altitude
Start Time	14:15:37 (51337)	**Aircraft**	DNSC Twin Otter
Stop Time	15:13:58 (54838)	**Retracker**	OCOG
Distance	243.583 km	**INS Resolution**	50 Hz
Duration	00 h 58 m 22 s	**Processor Version**	0403

A120402_03

AS30A03_ASIWL1B040320120402T151402_20120402T161501_0001.DBL

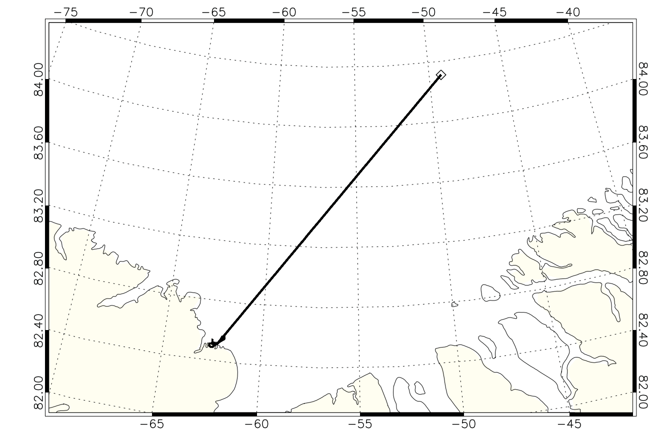


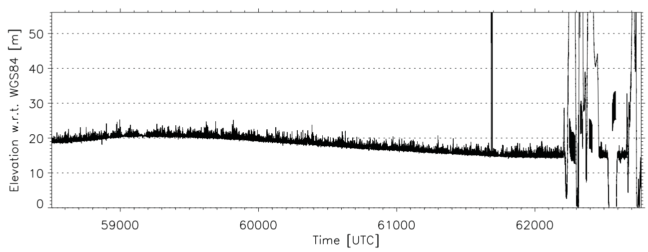


Date	2012-04-02	**Instrument Mode**	Adv. Low Altitude
Start Time	15:14:02 (54842)	**Aircraft**	DNSC Twin Otter
Stop Time	16:15:00 (58500)	**Retracker**	OCOG
Distance	249.494 km	**INS Resolution**	50 Hz
Duration	01 h 00 m 59 s	**Processor Version**	0403

A120402_04

AS30A04_ASIWL1B040320120402T161504_20120402T172609_0001.DBL

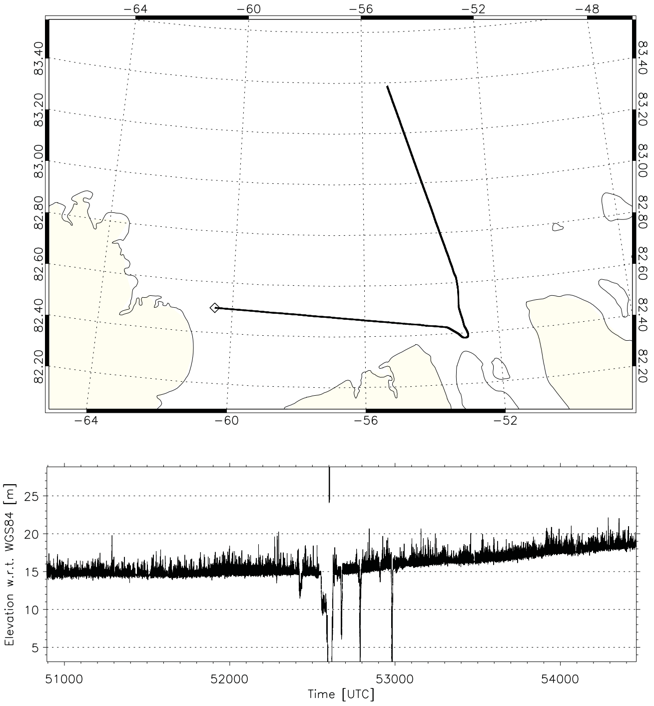




Date	2012-04-02	**Instrument Mode**	Adv. Low Altitude
Start Time	16:15:04 (58504)	**Aircraft**	DNSC Twin Otter
Stop Time	17:26:08 (62768)	**Retracker**	OCOG
Distance	294.284 km	**INS Resolution**	50 Hz
Duration	01 h 11 m 05 s	**Processor Version**	0403

A120403_00

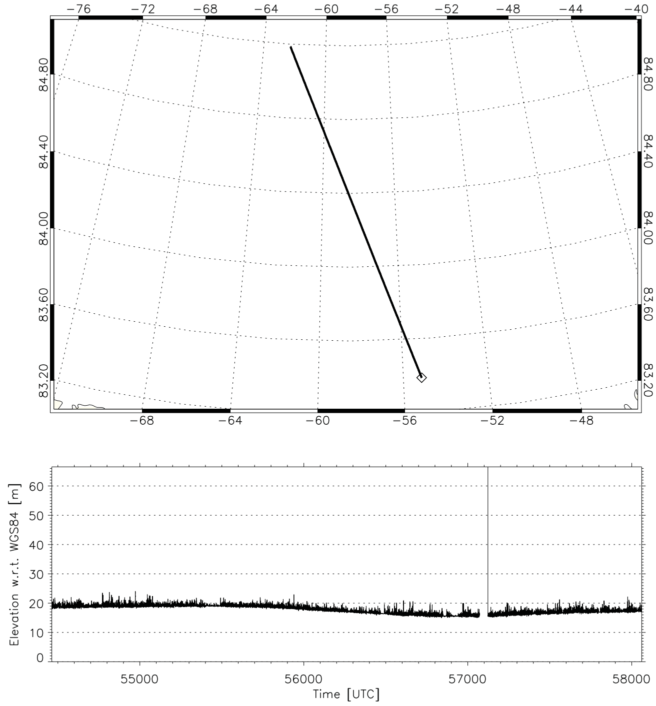
AS30A00_ASIWL1B040320120403T140814_20120403T150740_0001.DBL



Date	2012-04-03	**Instrument Mode**	Adv. Low Altitude
Start Time	14:08:14 (50894)	**Aircraft**	DNSC Twin Otter
Stop Time	15:07:39 (54459)	**Retracker**	OCOG
Distance	228.429 km	**INS Resolution**	50 Hz
Duration	00 h 59 m 25 s	**Processor Version**	0403

A120403_01

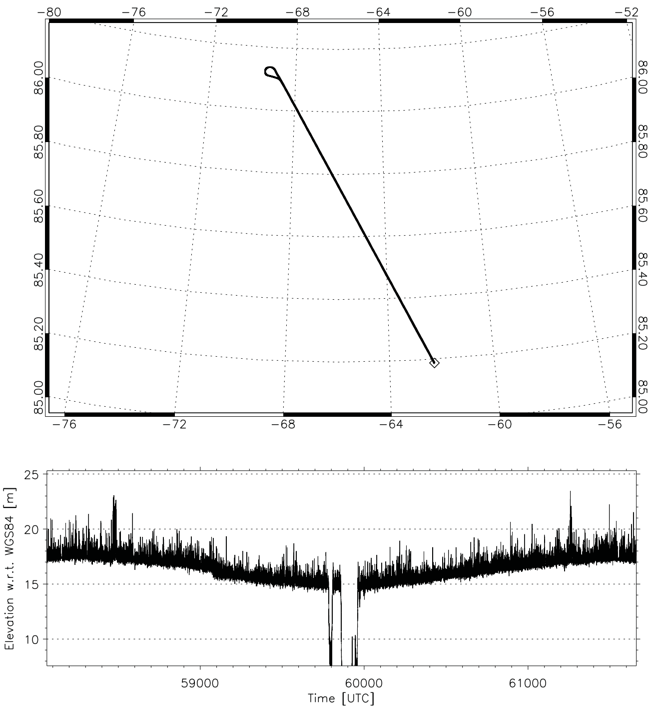
AS30A01_ASIWL1B040320120403T150743_20120403T160741_0001.DBL



Date	2012-04-03	**Instrument Mode**	Adv. Low Altitude
Start Time	15:07:43 (54463)	**Aircraft**	DNSC Twin Otter
Stop Time	16:07:40 (58060)	**Retracker**	OCOG
Distance	214.693 km	**INS Resolution**	50 Hz
Duration	00 h 59 m 58 s	**Processor Version**	0403

A120403_02

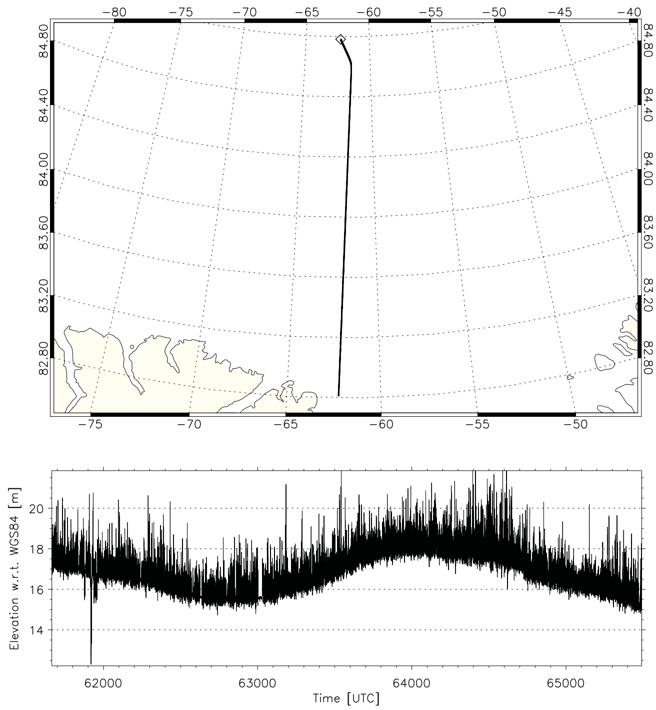
AS30A02_ASIWL1B040320120403T160744_20120403T170741_0001.DBL



Date	2012-04-03	**Instrument Mode**	Adv. Low Altitude
Start Time	16:07:44 (58064)	**Aircraft**	DNSC Twin Otter
Stop Time	17:07:40 (61660)	**Retracker**	OCOG
Distance	244.691 km	**INS Resolution**	50 Hz
Duration	00 h 59 m 57 s	**Processor Version**	0403

A120403_03

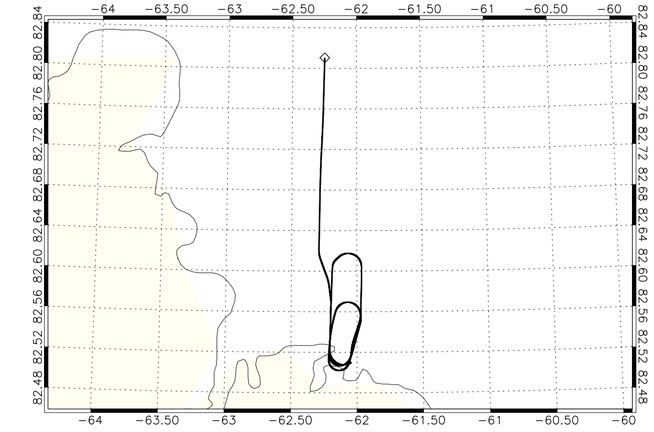
AS30A03_ASIWL1B040320120403T170745_20120403T181131_0001.DBL

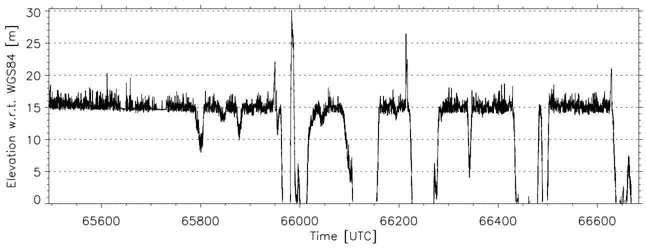


Date	2012-04-03	**Instrument Mode**	Adv. Low Altitude
Start Time	17:07:45 (61665)	**Aircraft**	DNSC Twin Otter
Stop Time	18:11:31 (65491)	**Retracker**	OCOG
Distance	265.386 km	**INS Resolution**	50 Hz
Duration	01 h 03 m 46 s	**Processor Version**	0403

A120403_04

AS30A04_ASIWL1B040320120403T181134_20120403T183124_0001.DBL

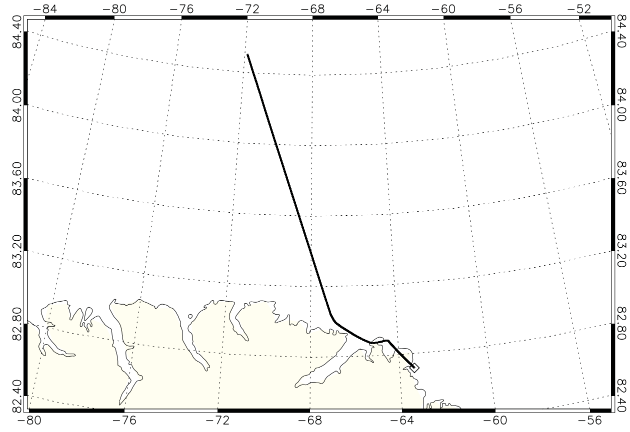


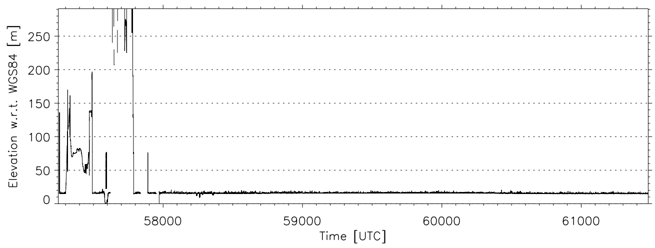


Date	2012-04-03	**Instrument Mode**	Adv. Low Altitude
Start Time	18:11:34 (65494)	**Aircraft**	DNSC Twin Otter
Stop Time	18:31:23 (66683)	**Retracker**	OCOG
Distance	81.575 km	**INS Resolution**	50 Hz
Duration	00 h 19 m 50 s	**Processor Version**	0403

A120404_00

AS30A00_ASIWL1B040320120404T155408_20120404T160612_0001.DBL

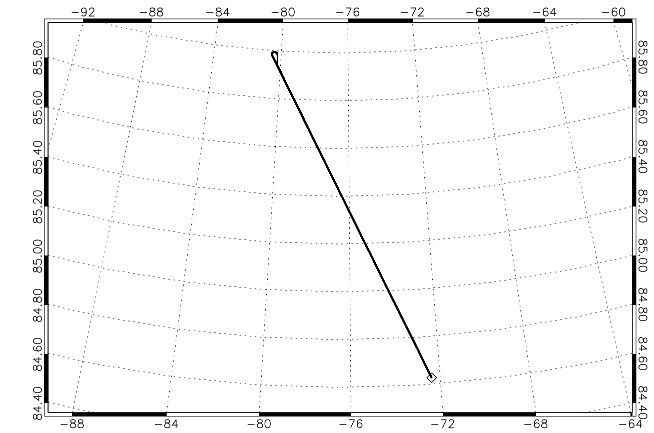


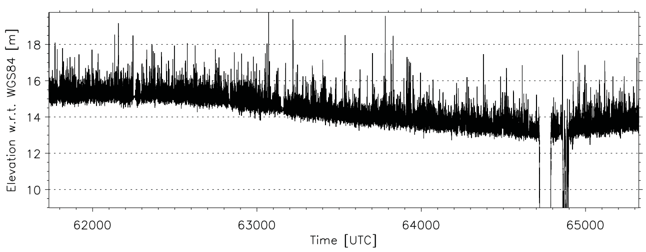


Date	2012-04-04	**Instrument Mode**	Adv. Low Altitude
Start Time	15:54:08 (57248)	**Aircraft**	DNSC Twin Otter
Stop Time	17:04:40 (61480)	**Retracker**	OCOG
Distance	238.477 km	**INS Resolution**	50 Hz
Duration	01 h 10 m 33 s	**Processor Version**	0403

A120404_01

AS30A01_ASIWL1B040320120404T170854_20120404T180844_0001.DBL

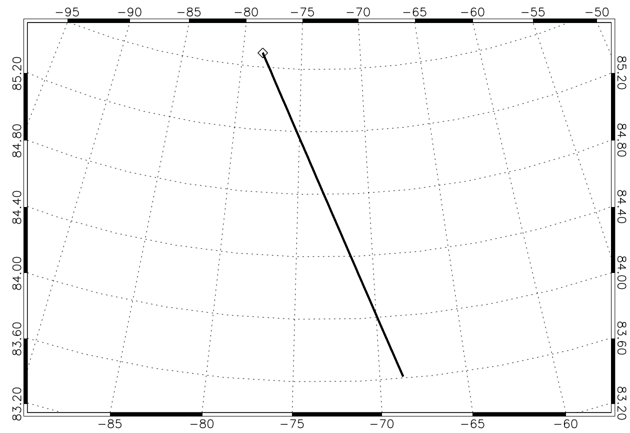


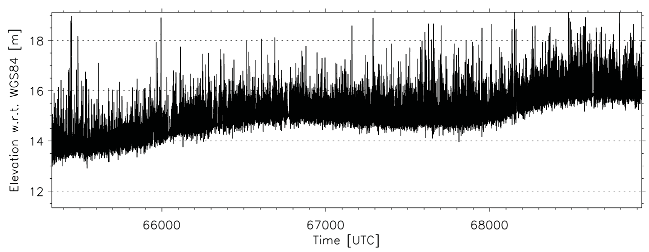


Date	2012-04-04	**Instrument Mode**	Adv. Low Altitude
Start Time	17:08:54 (61734)	**Aircraft**	DNSC Twin Otter
Stop Time	18:08:44 (65324)	**Retracker**	OCOG
Distance	208.156 km	**INS Resolution**	50 Hz
Duration	00 h 59 m 50 s	**Processor Version**	0403

A120404_02

AS30A02_ASIWL1B040320120404T180848_20120404T190848_0001.DBL

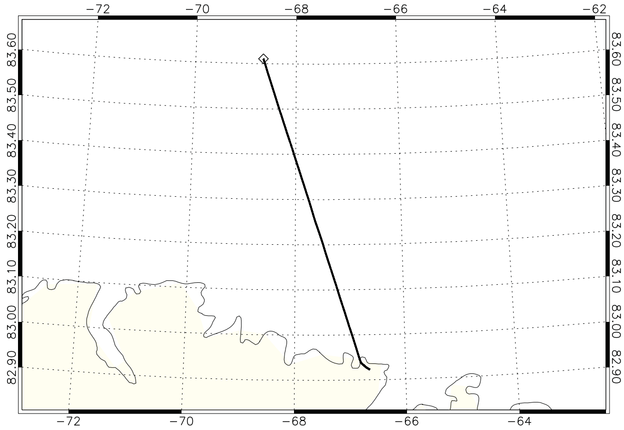


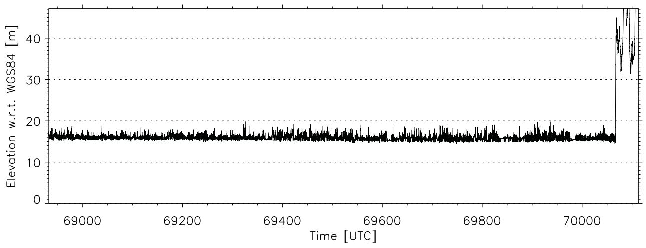


Date	2012-04-04	**Instrument Mode**	Adv. Low Altitude
Start Time	18:08:48 (65328)	**Aircraft**	DNSC Twin Otter
Stop Time	19:08:47 (68927)	**Retracker**	OCOG
Distance	251.311 km	**INS Resolution**	50 Hz
Duration	00 h 59 m 60 s	**Processor Version**	0403

A120404_03

AS30A03_ASIWL1B040320120404T190852_20120404T192833_0001.DBL

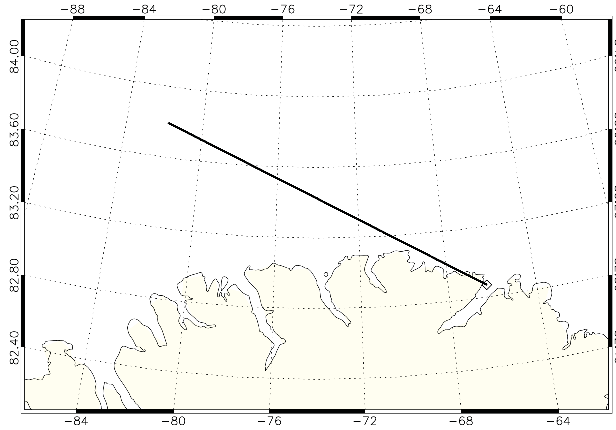


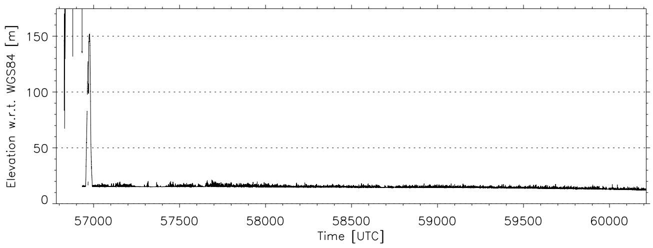


Date	2012-04-04	**Instrument Mode**	Adv. Low Altitude
Start Time	19:08:52 (68932)	**Aircraft**	DNSC Twin Otter
Stop Time	19:28:32 (70112)	**Retracker**	OCOG
Distance	81.176 km	**INS Resolution**	50 Hz
Duration	00 h 19 m 41 s	**Processor Version**	0403

A120405_00

AS30A00_ASIWL1B040320120405T154623_20120405T164334_0001.DBL

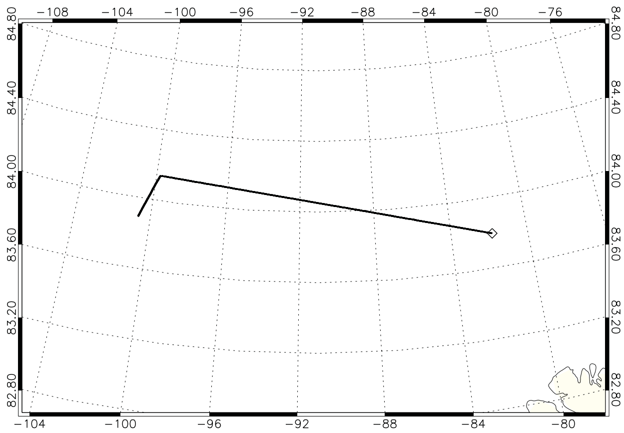


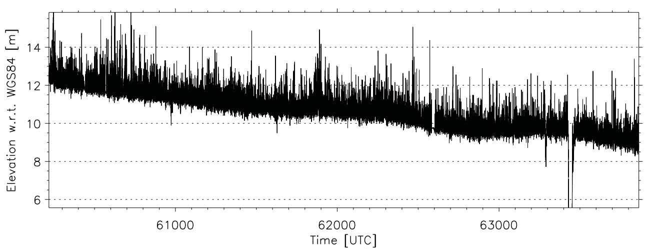


Date	2012-04-05	**Instrument Mode**	Adv. Low Altitude
Start Time	15:46:23 (56783)	**Aircraft**	DNSC Twin Otter
Stop Time	16:43:33 (60213)	**Retracker**	OCOG
Distance	224.596 km	**INS Resolution**	50 Hz
Duration	00 h 57 m 10 s	**Processor Version**	0403

A120405_01

AS30A01_ASIWL1B040320120405T164338_20120405T174424_0001.DBL

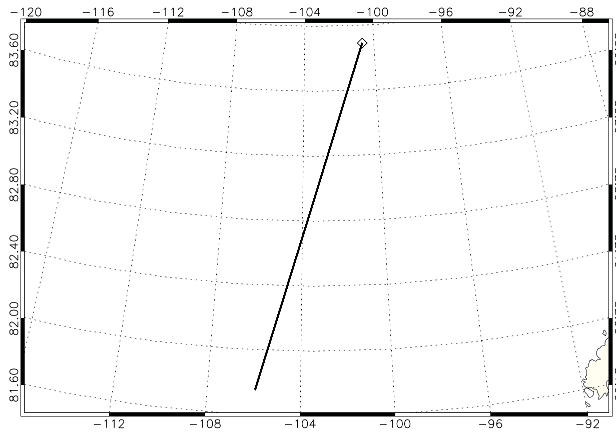


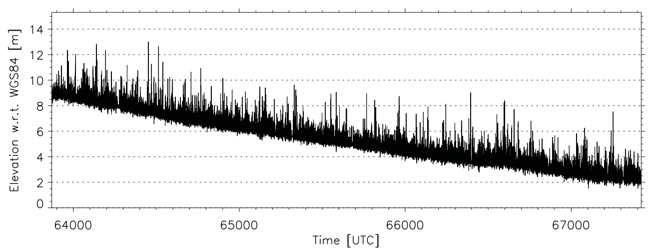


Date	2012-04-05	**Instrument Mode**	Adv. Low Altitude
Start Time	16:43:38 (60218)	**Aircraft**	DNSC Twin Otter
Stop Time	17:44:23 (63863)	**Retracker**	OCOG
Distance	241.134 km	**INS Resolution**	50 Hz
Duration	01 h 00 m 46 s	**Processor Version**	0403

A120405_02

AS30A02_ASIWL1B040320120405T174430_20120405T184342_0001.DBL

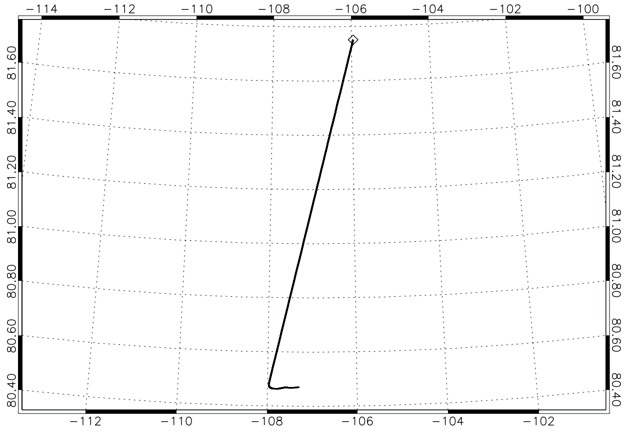


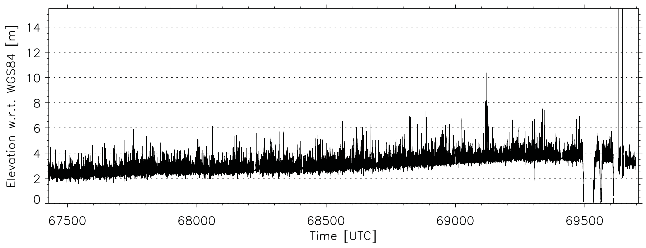


Date	2012-04-05	**Instrument Mode**	Adv. Low Altitude
Start Time	17:44:30 (63870)	**Aircraft**	DNSC Twin Otter
Stop Time	18:43:42 (67422)	**Retracker**	OCOG
Distance	247.997 km	**INS Resolution**	50 Hz
Duration	00 h 59 m 12 s	**Processor Version**	0403

A120405_03

AS3OA03_ASIWL1B040320120405T184347_20120405T192148_0001.DBL

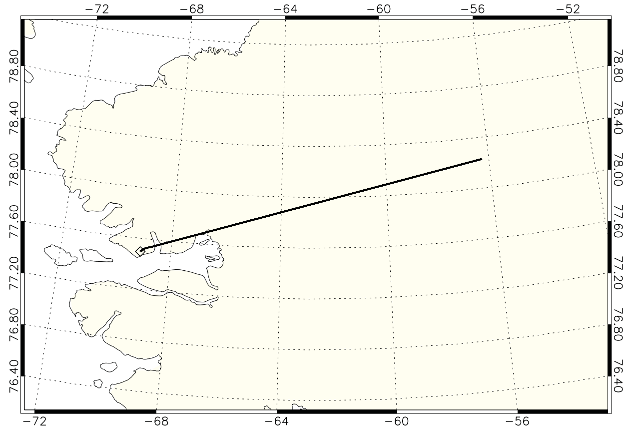


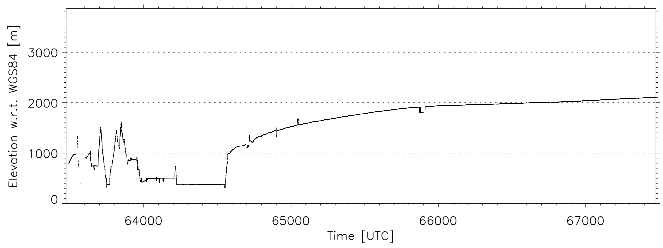


Date	2012-04-05	**Instrument Mode**	Adv. Low Altitude
Start Time	18:43:47 (67427)	**Aircraft**	DNSC Twin Otter
Stop Time	19:21:47 (69707)	**Retracker**	OCOG
Distance	159.251 km	**INS Resolution**	50 Hz
Duration	00 h 38 m 01 s	**Processor Version**	0403

A120406_00

AS3OA00_ASIWL1B040320120406T173753_20120406T184437_0001.DBL

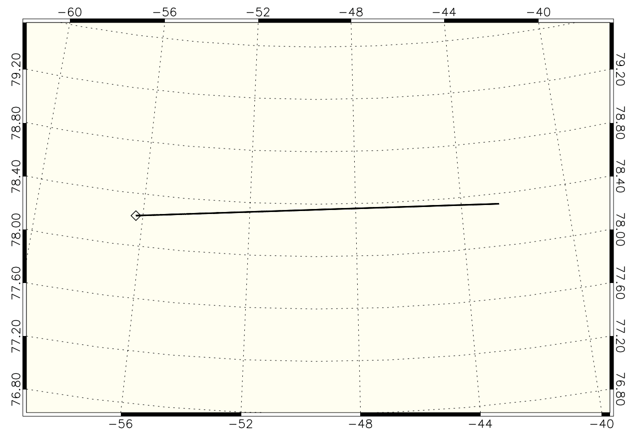


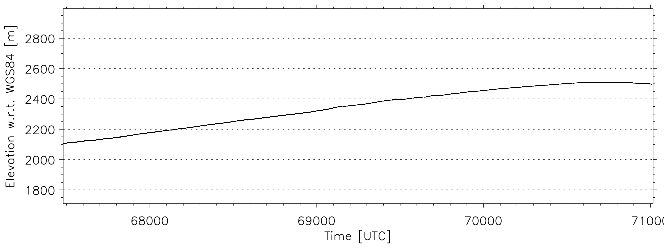


Date	2012-04-06	**Instrument Mode**	Adv. Low Altitude
Start Time	17:37:53 (63473)	**Aircraft**	DNSC Twin Otter
Stop Time	18:44:36 (67476)	**Retracker**	OCOG
Distance	310.591 km	**INS Resolution**	50 Hz
Duration	01 h 06 m 44 s	**Processor Version**	0403

A120406_01

AS3OA01_ASIWL1B040320120406T184440_20120406T194336_0001.DBL

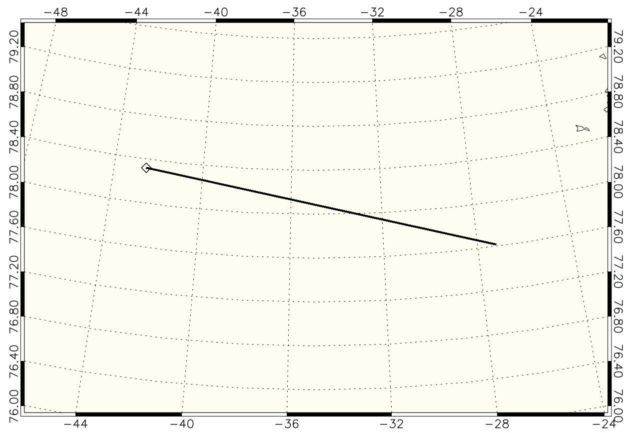


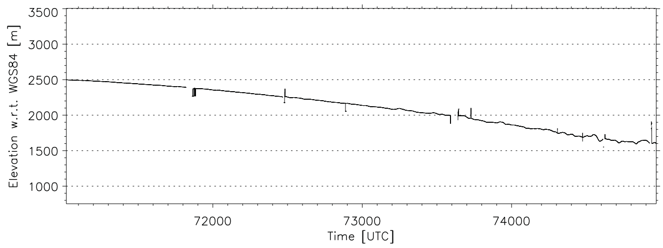


Date	2012-04-06	**Instrument Mode**	Adv. Low Altitude
Start Time	18:44:40 (67480)	**Aircraft**	DNSC Twin Otter
Stop Time	19:43:35 (71015)	**Retracker**	OCOG
Distance	309.003 km	**INS Resolution**	50 Hz
Duration	00 h 58 m 56 s	**Processor Version**	0403

A120406_02

AS3OA02_ASIWL1B040320120406T194339_20120406T204928_0001.DBL

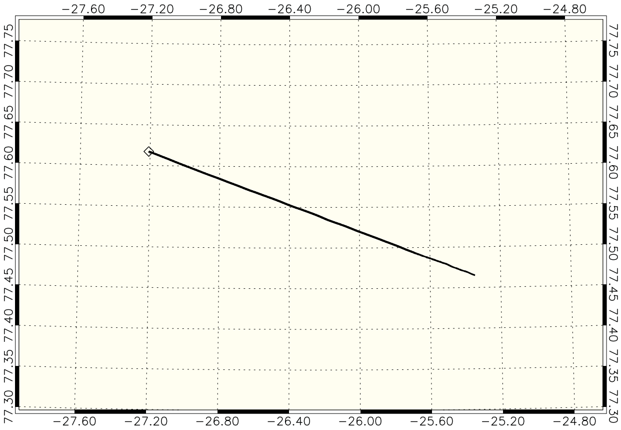


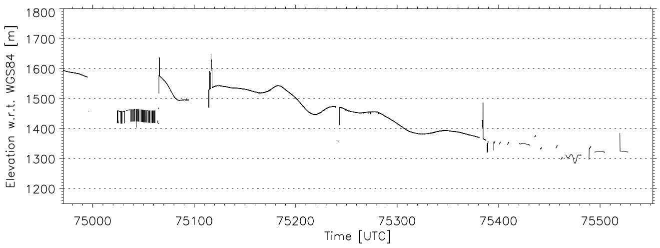


Date	2012-04-06	**Instrument Mode**	Adv. Low Altitude
Start Time	19:43:39 (71019)	**Aircraft**	DNSC Twin Otter
Stop Time	20:49:28 (74968)	**Retracker**	OCOG
Distance	363.188 km	**INS Resolution**	50 Hz
Duration	01 h 05 m 49 s	**Processor Version**	0403

A120406_03

AS30A03_ASIWL1B040320120406T204931_20120406T205915_0001.DBL

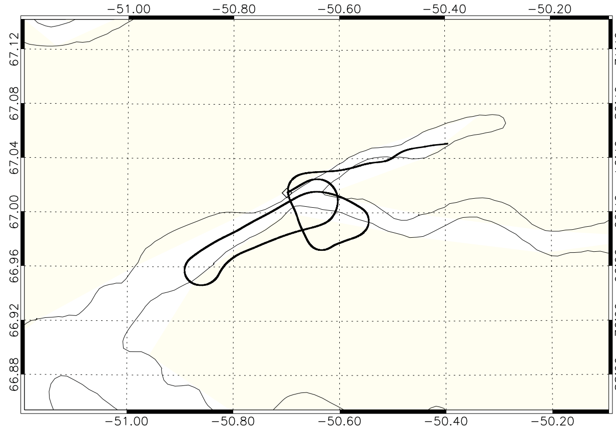


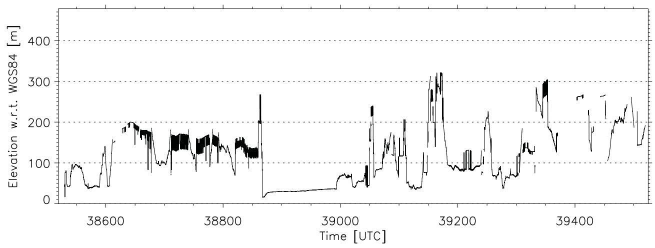


Date	2012-04-06	**Instrument Mode**	Adv. Low Altitude
Start Time	20:49:31 (74971)	**Aircraft**	DNSC Twin Otter
Stop Time	20:59:12 (75552)	**Retracker**	OCOG
Distance	47.762 km	**INS Resolution**	50 Hz
Duration	00 h 09 m 41 s	**Processor Version**	0403

A120424_00

AS30A00_ASIWL1B040320120424T104159_20120424T105845_0001.DBL

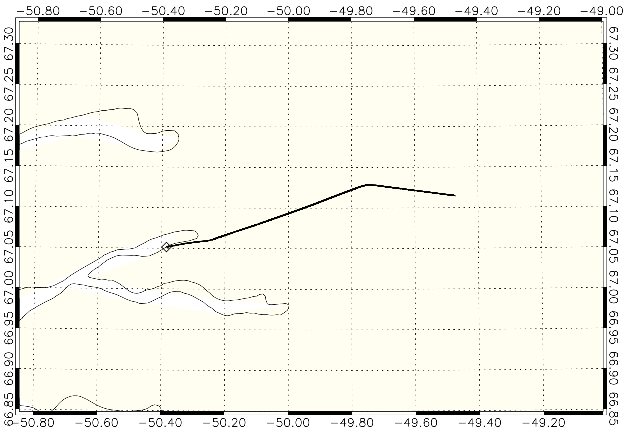


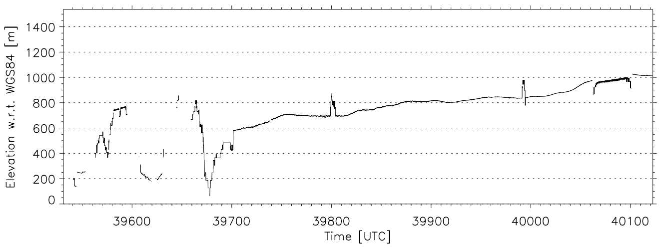


Date	2012-04-24	**Instrument Mode**	Adv. Low Altitude
Start Time	10:41:59 (38519)	**Aircraft**	DNSC Twin Otter
Stop Time	10:58:44 (39524)	**Retracker**	OCOG
Distance	64.599 km	**INS Resolution**	50 Hz
Duration	00 h 16 m 46 s	**Processor Version**	0403

A120424_01

AS30A01_ASIWL1B040320120424T105851_20120424T111143_0001.DBL

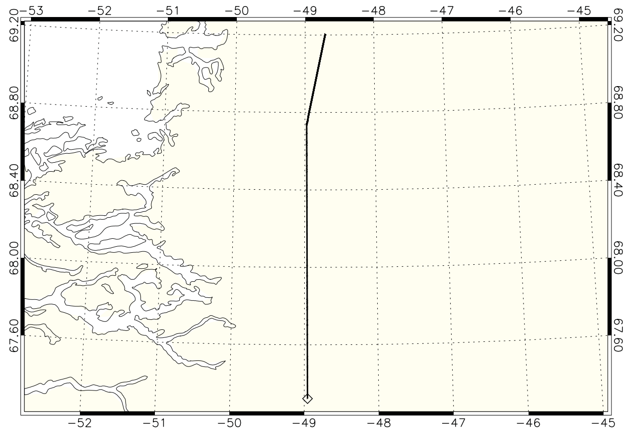


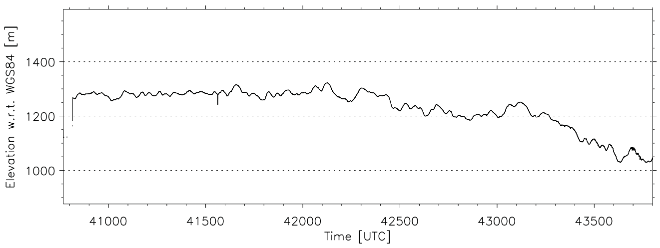


Date	2012-04-24	**Instrument Mode**	Adv. Low Altitude
Start Time	10:58:51 (39531)	**Aircraft**	DNSC Twin Otter
Stop Time	11:08:42 (40122)	**Retracker**	OCOG
Distance	40.993 km	**INS Resolution**	50 Hz
Duration	00 h 09 m 51 s	**Processor Version**	0403

A120424_02

AS30A02_ASIWL1B040320120424T111927_20120424T121001_0001.DBL

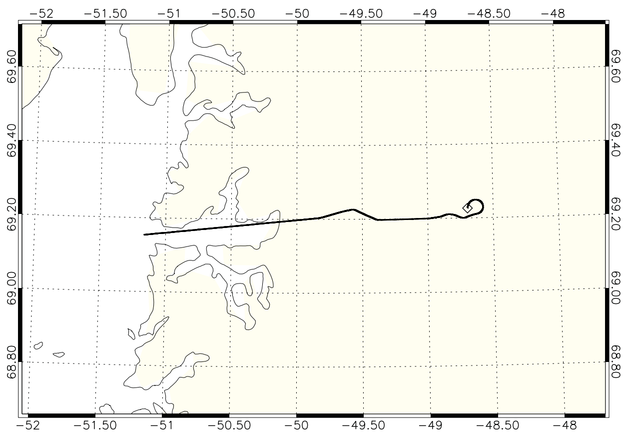


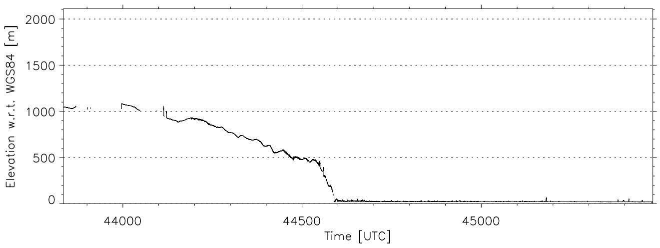


Date	2012-04-24	**Instrument Mode**	Adv. Low Altitude
Start Time	11:19:27 (40767)	**Aircraft**	DNSC Twin Otter
Stop Time	12:10:00 (43800)	**Retracker**	OCOG
Distance	210.415 km	**INS Resolution**	50 Hz
Duration	00 h 50 m 34 s	**Processor Version**	0403

A120424_03

AS30A03_ASIWL1B040320120424T121034_20120424T123759_0001.DBL

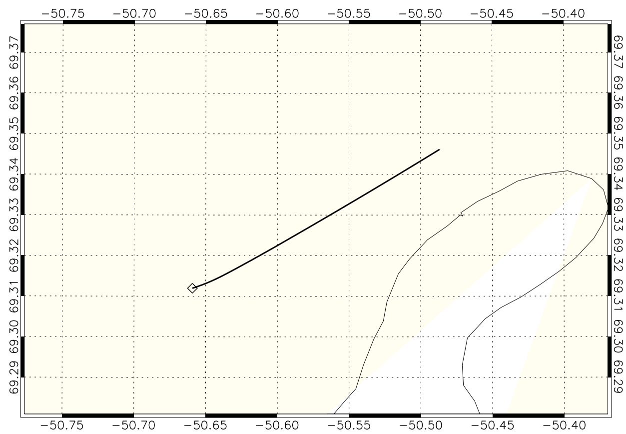


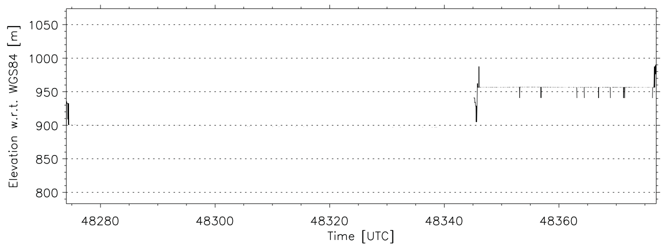


Date	2012-04-24	**Instrument Mode**	Adv. Low Altitude
Start Time	12:10:34 (43834)	**Aircraft**	DNSC Twin Otter
Stop Time	12:37:58 (45478)	**Retracker**	OCOG
Distance	112.817 km	**INS Resolution**	50 Hz
Duration	00 h 27 m 25 s	**Processor Version**	0403

A120424_04

AS30A04_ASIWL1B040320120424T132434_20120424T132617_0001.DBL

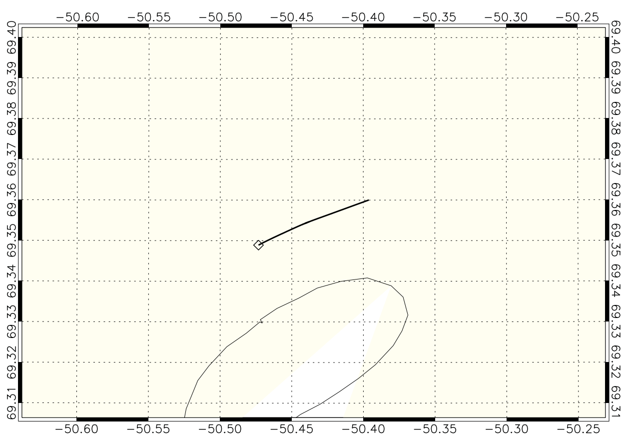


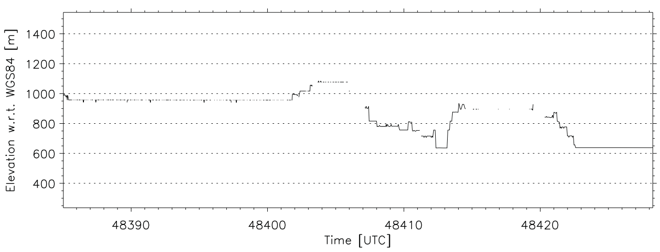


Date	2012-04-24	**Instrument Mode**	Adv. Low Altitude
Start Time	13:24:34 (48274)	**Aircraft**	DNSC Twin Otter
Stop Time	13:26:16 (48376)	**Retracker**	OCOG
Distance	7.784 km	**INS Resolution**	50 Hz
Duration	00 h 01 m 43 s	**Processor Version**	0403

A120424_05

AS30A05_ASIWL1B040320120424T132625_20120424T132709_0001.DBL

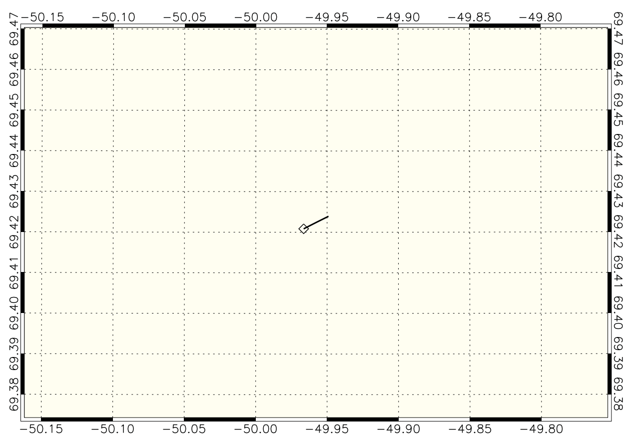




Date	2012-04-24	**Instrument Mode**	Adv. Low Altitude
Start Time	13:26:25 (48385)	**Aircraft**	DNSC Twin Otter
Stop Time	13:27:08 (48428)	**Retracker**	OCOG
Distance	3.276 km	**INS Resolution**	50 Hz
Duration	00 h 00 m 43 s	**Processor Version**	0403

A120424_06

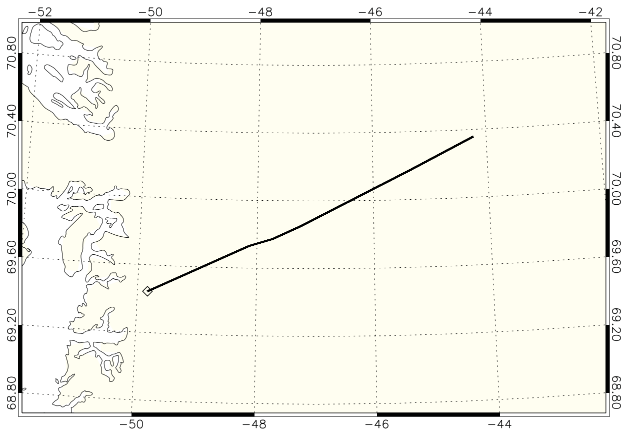
AS30A06_ASIWL1B040320120424T133112_20120424T133123_0001.DBL

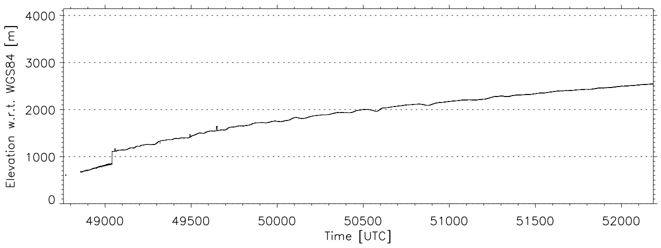


Date	2012-04-24	**Instrument Mode**	Adv. Low Altitude
Start Time	13:31:12 (48672)	**Aircraft**	DNSC Twin Otter
Stop Time	13:31:22 (48682)	**Retracker**	OCOG
Distance	0.761 km	**INS Resolution**	50 Hz
Duration	00 h 00 m 11 s	**Processor Version**	0403

A120424_07

AS30A07_ASIWL1B040320120424T133238_20120424T142945_0001.DBL

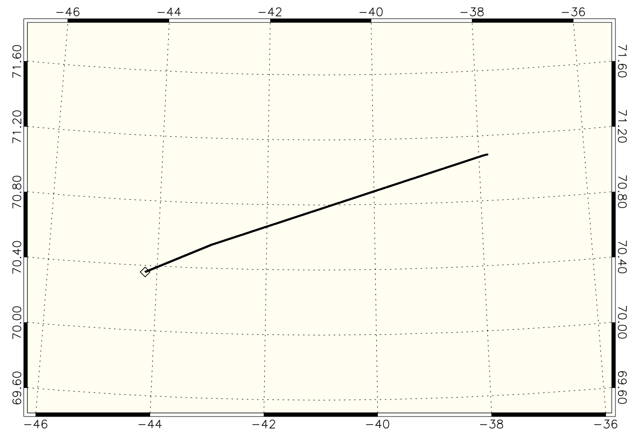


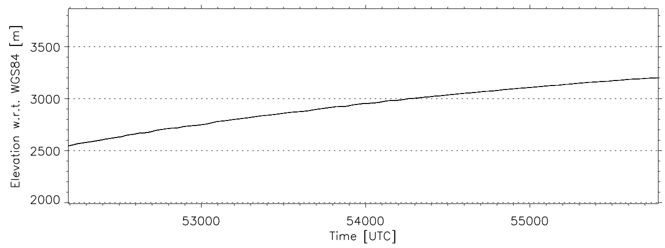


Date	2012-04-24	Instrument Mode	Adv. Low Altitude
Start Time	13:32:38 (48758)	Aircraft	DNSC Twin Otter
Stop Time	14:29:44 (52184)	Retracker	OCOG
Distance	237.194 km	INS Resolution	50 Hz
Duration	00 h 57 m 07 s	Processor Version	0403

A120424_08

AS30A08_ASIWL1B040320120424T142950_20120424T152941_0001.DBL

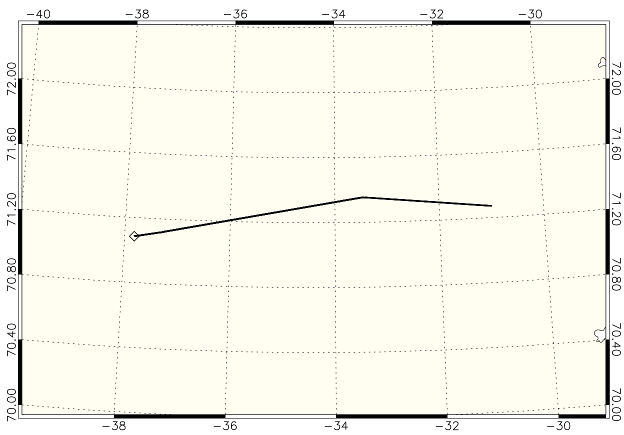


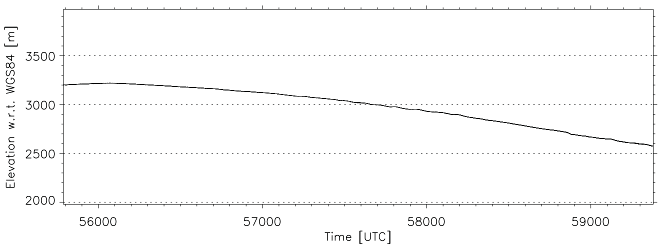


Date	2012-04-24	Instrument Mode	Adv. Low Altitude
Start Time	14:29:50 (52190)	Aircraft	DNSC Twin Otter
Stop Time	15:29:41 (55781)	Retracker	OCOG
Distance	247.411 km	INS Resolution	50 Hz
Duration	00 h 59 m 51 s	Processor Version	0403

A120424_09

AS30A09_ASIWL1B040320120424T152947_20120424T162941_0001.DBL

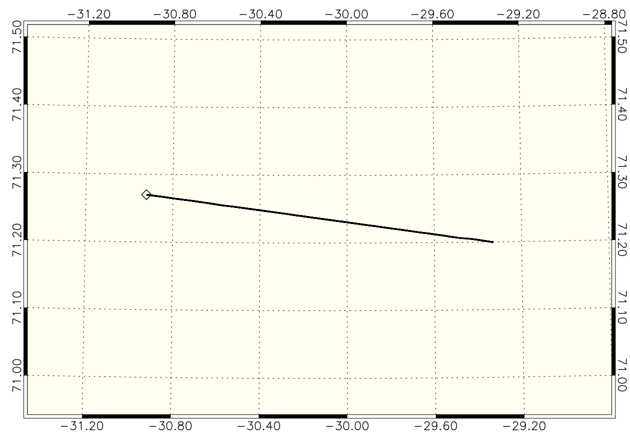


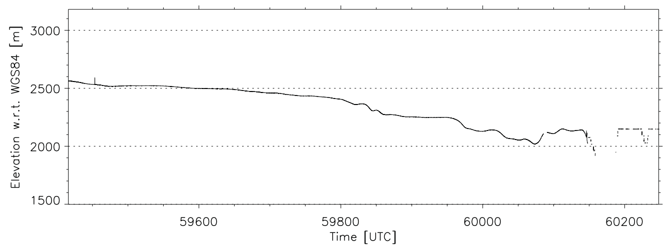


Date	2012-04-24	Instrument Mode	Adv. Low Altitude
Start Time	15:29:47 (55787)	Aircraft	DNSC Twin Otter
Stop Time	16:29:40 (59380)	Retracker	OCOG
Distance	246.937 km	INS Resolution	50 Hz
Duration	00 h 59 m 54 s	Processor Version	0403

A120424_10

AS30A10_ASIWL1B040320120424T163016_20120424T164408_0001.DBL

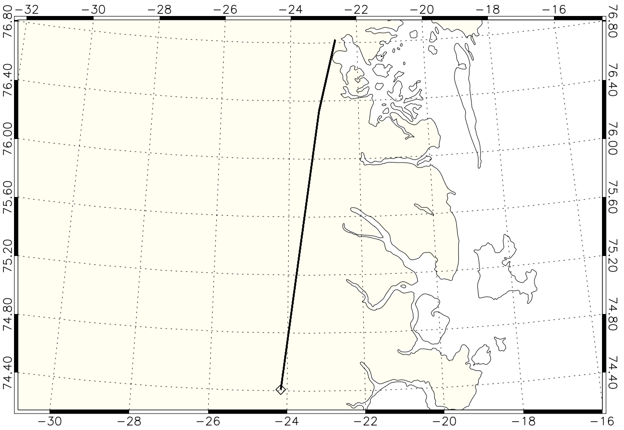


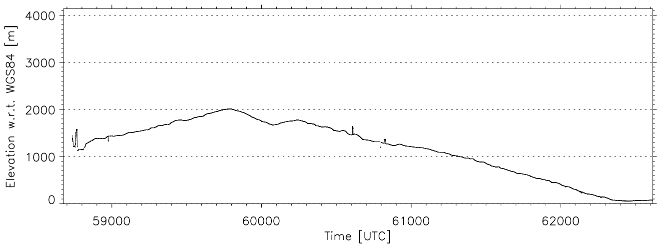


Date	2012-04-24	Instrument Mode	Adv. Low Altitude
Start Time	16:30:16 (59416)	Aircraft	DNSC Twin Otter
Stop Time	16:44:08 (60248)	Retracker	OCOG
Distance	57.432 km	INS Resolution	50 Hz
Duration	00 h 13 m 52 s	Processor Version	0403

A120425_00

AS3OA00_ASIWL1B040320120425T161756_20120425T172335_0001.DBL

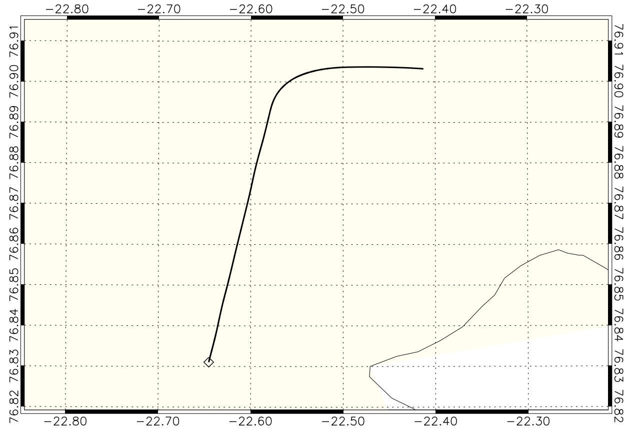


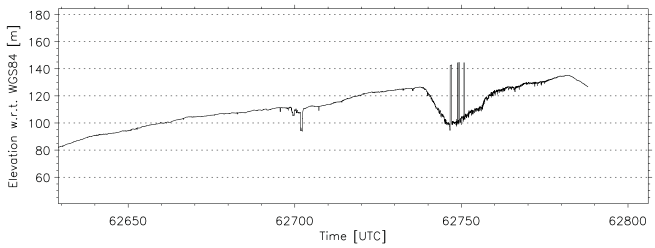


Date	2012-04-25	**Instrument Mode**	Adv. Low Altitude
Start Time	16:17:56 (58676)	**Aircraft**	DNSC Twin Otter
Stop Time	17:23:34 (62614)	**Retracker**	OCOG
Distance	271.999 km	**INS Resolution**	50 Hz
Duration	01 h 05 m 39 s	**Processor Version**	0403

A120425_01

AS3OA01_ASIWL1B040320120425T172349_20120425T172646_0001.DBL

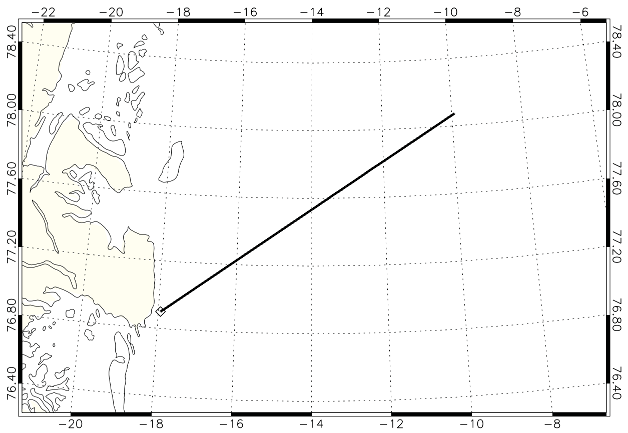


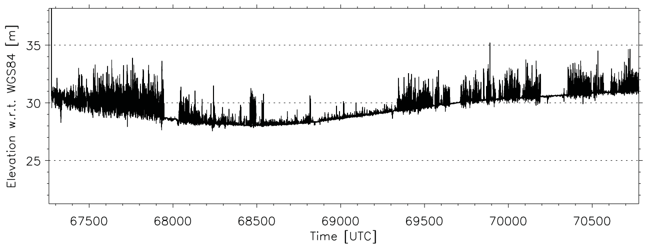


Date	2012-04-25	**Instrument Mode**	Adv. Low Altitude
Start Time	17:23:49 (62629)	**Aircraft**	DNSC Twin Otter
Stop Time	17:26:46 (62806)	**Retracker**	OCOG
Distance	11.778 km	**INS Resolution**	50 Hz
Duration	00 h 02 m 57 s	**Processor Version**	0403

A120425_02

AS3OA02_ASIWL1B040320120425T184100_20120425T193938_0001.DBL

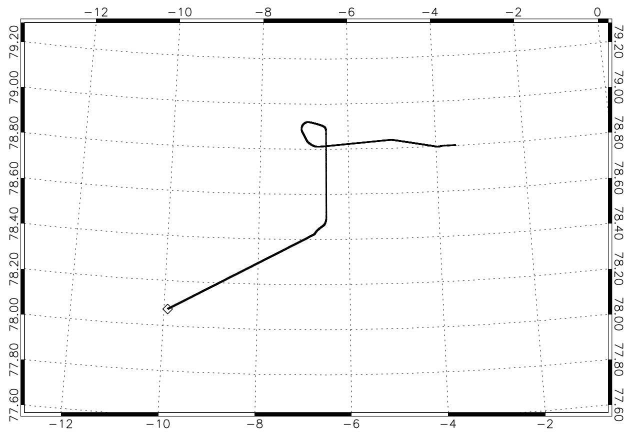


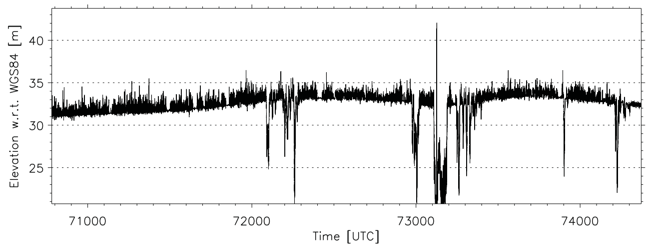


Date	2012-04-25	**Instrument Mode**	Adv. Low Altitude
Start Time	18:41:00 (67260)	**Aircraft**	DNSC Twin Otter
Stop Time	19:39:37 (70777)	**Retracker**	OCOG
Distance	232.446 km	**INS Resolution**	50 Hz
Duration	00 h 58 m 38 s	**Processor Version**	0403

A120425_03

AS3OA03_ASIWL1B040320120425T193941_20120425T203932_0001.DBL

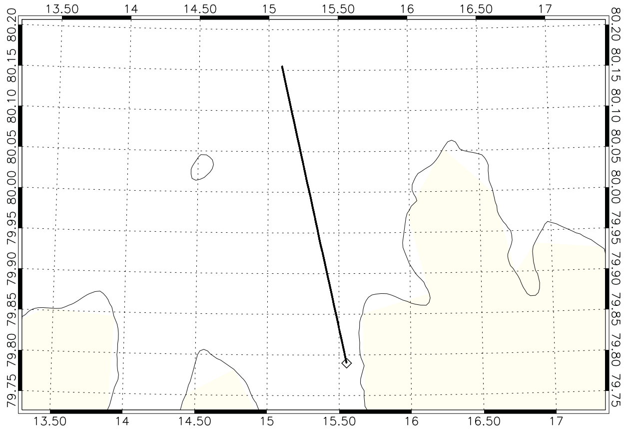


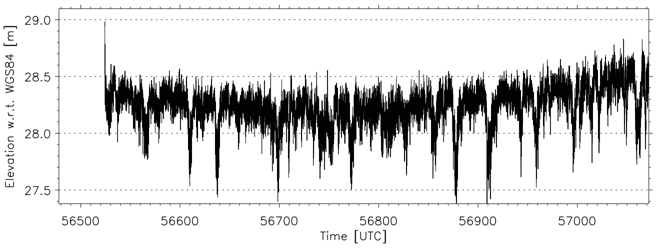


Date	2012-04-25	**Instrument Mode**	Adv. Low Altitude
Start Time	19:39:41 (70781)	**Aircraft**	DNSC Twin Otter
Stop Time	20:39:32 (74372)	**Retracker**	OCOG
Distance	231.927 km	**INS Resolution**	50 Hz
Duration	00 h 59 m 51 s	**Processor Version**	0403

A120427_00

AS30A00_ASIWL1B040320120427T154118_20120427T155112_0001.DBL

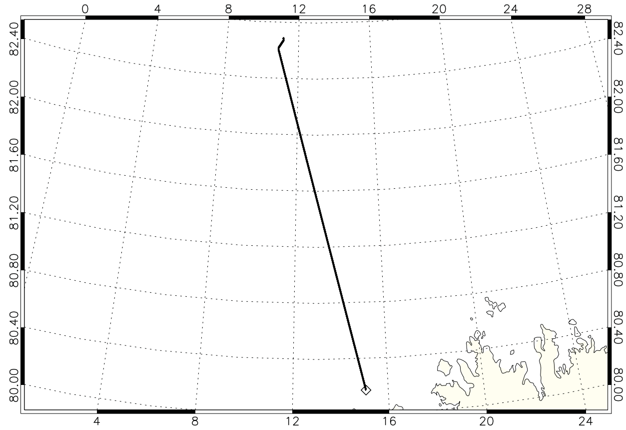


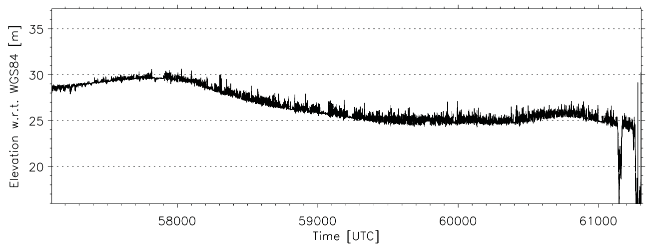


Date	2012-04-27	**Instrument Mode**	Adv. Low Altitude
Start Time	15:41:18 (56478)	**Aircraft**	DNSC Twin Otter
Stop Time	15:51:11 (57071)	**Retracker**	OCOG
Distance	41.514 km	**INS Resolution**	50 Hz
Duration	00 h 09 m 54 s	**Processor Version**	0403

A120427_01

AS30A01_ASIWL1B040320120427T155145_20120427T170144_0001.DBL

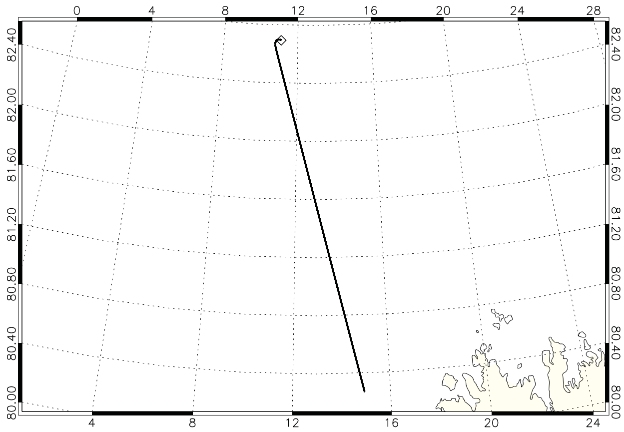


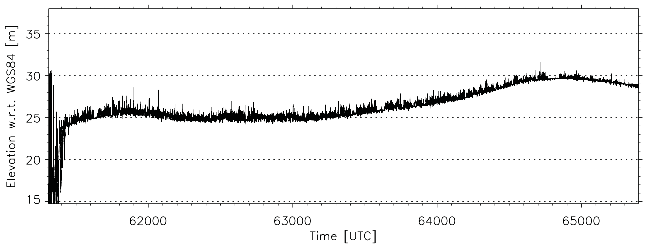


Date	2012-04-27	**Instrument Mode**	Adv. Low Altitude
Start Time	15:51:45 (57105)	**Aircraft**	DNSC Twin Otter
Stop Time	17:01:43 (61303)	**Retracker**	OCOG
Distance	289.929 km	**INS Resolution**	50 Hz
Duration	01 h 09 m 59 s	**Processor Version**	0403

A120427_02

AS30A02_ASIWL1B040320120427T170150_20120427T180955_0001.DBL

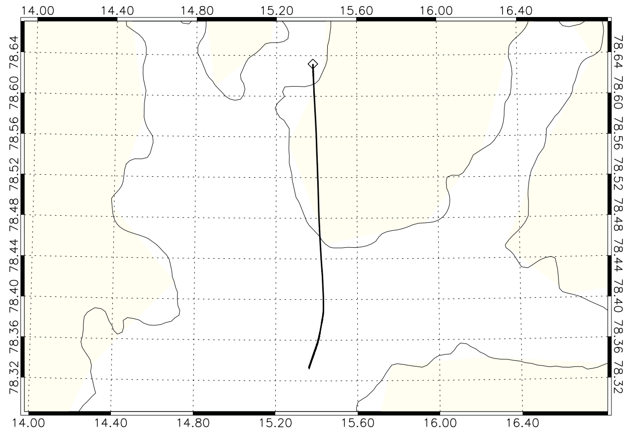


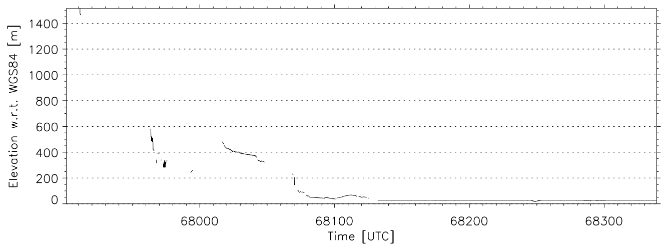


Date	2012-04-27	**Instrument Mode**	Adv. Low Altitude
Start Time	17:01:50 (61310)	**Aircraft**	DNSC Twin Otter
Stop Time	18:09:54 (65394)	**Retracker**	OCOG
Distance	282.146 km	**INS Resolution**	50 Hz
Duration	01 h 08 m 05 s	**Processor Version**	0403

A120427_03

AS30A03_ASIWL1B040320120427T185141_20120427T185859_0001.DBL

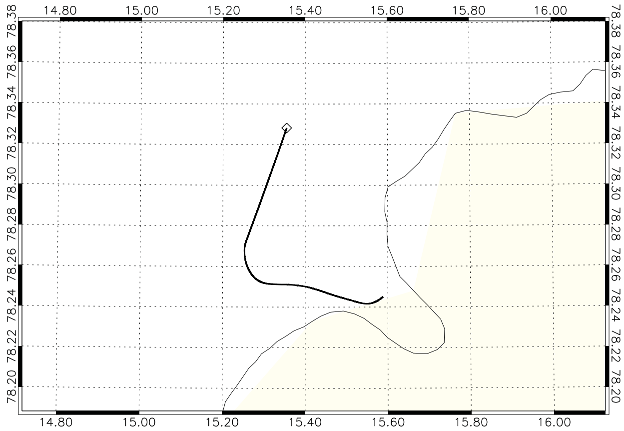


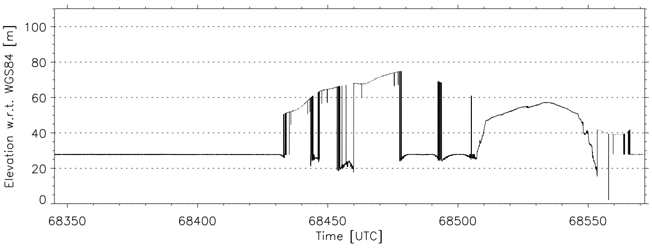


Date	2012-04-27	**Instrument Mode**	Adv. Low Altitude
Start Time	18:51:41 (67901)	**Aircraft**	DNSC Twin Otter
Stop Time	18:58:58 (68338)	**Retracker**	OCOG
Distance	33.624 km	**INS Resolution**	50 Hz
Duration	00 h 07 m 18 s	**Processor Version**	0403

A120427_04

AS30A04_ASIWL1B040320120427T185905_20120427T190252_0001.DBL

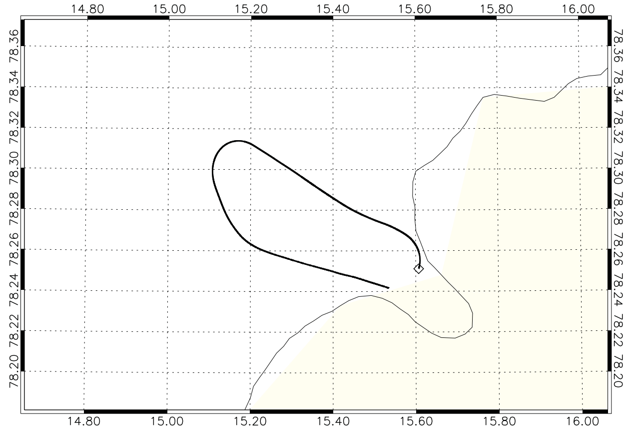


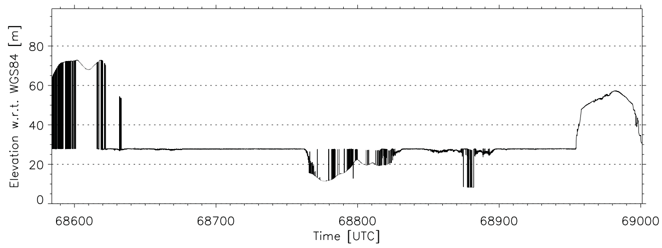


Date	2012-04-27	**Instrument Mode**	Adv. Low Altitude
Start Time	18:59:05 (68345)	**Aircraft**	DNSC Twin Otter
Stop Time	19:02:51 (68571)	**Retracker**	OCOG
Distance	16.141 km	**INS Resolution**	50 Hz
Duration	00 h 03 m 47 s	**Processor Version**	0403

A120427_05

AS30A05_ASIWL1B040320120427T190304_20120427T191001_0001.DBL

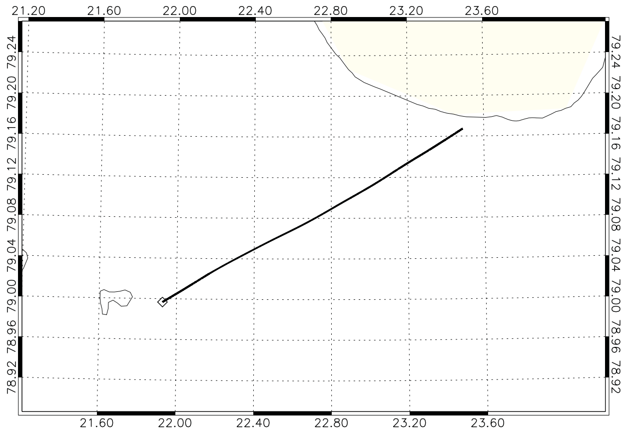


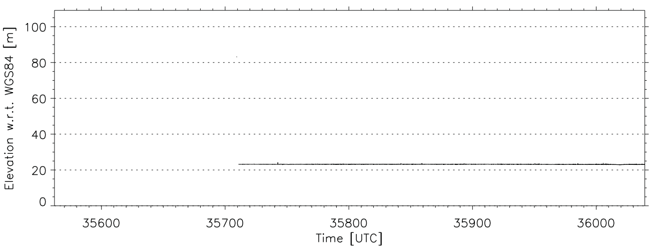


Date	2012-04-27	**Instrument Mode**	Adv. Low Altitude
Start Time	19:03:04 (68584)	**Aircraft**	DNSC Twin Otter
Stop Time	19:10:00 (69000)	**Retracker**	OCOG
Distance	27.769 km	**INS Resolution**	50 Hz
Duration	00 h 06 m 57 s	**Processor Version**	0403

A120428_00

AS30A00_ASIWL1B040320120428T095243_20120428T100041_0001.DBL

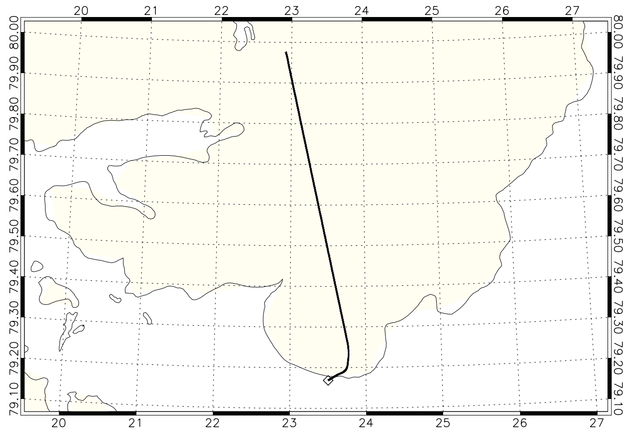


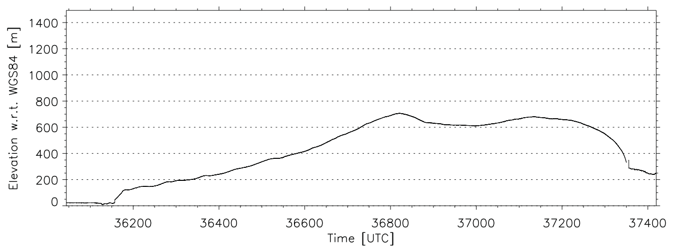


Date	2012-04-28	**Instrument Mode**	Adv. Low Altitude
Start Time	09:52:42 (35562)	**Aircraft**	DNSC Twin Otter
Stop Time	10:00:39 (36039)	**Retracker**	OCOG
Distance	38.013 km	**INS Resolution**	50 Hz
Duration	00 h 07 m 57 s	**Processor Version**	0403

A120428_01

AS30A01_ASIWL1B040320120428T100045_20120428T102341_0001.DBL

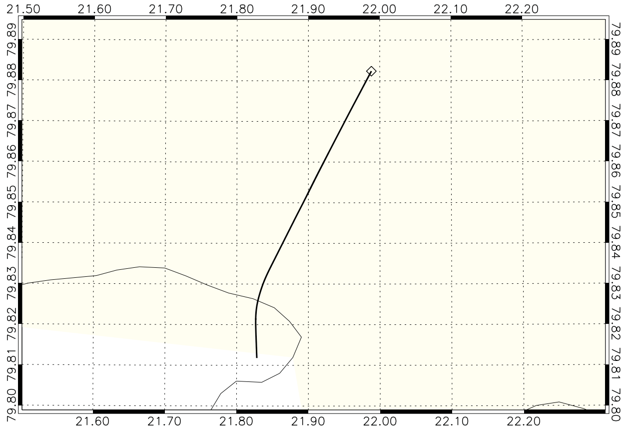


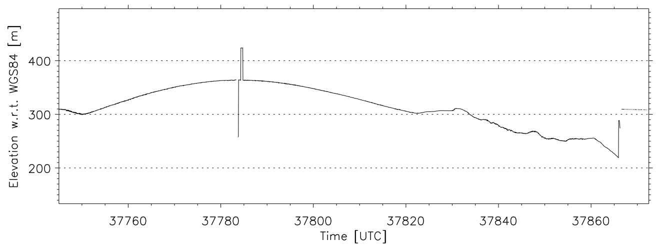


Date	2012-04-28	**Instrument Mode**	Adv. Low Altitude
Start Time	10:00:44 (36044)	**Aircraft**	DNSC Twin Otter
Stop Time	10:23:39 (37419)	**Retracker**	OCOG
Distance	94.416 km	**INS Resolution**	50 Hz
Duration	00 h 22 m 55 s	**Processor Version**	0403

A120428_02

AS30A02_ASIWL1B040320120428T102906_20120428T103114_0001.DBL

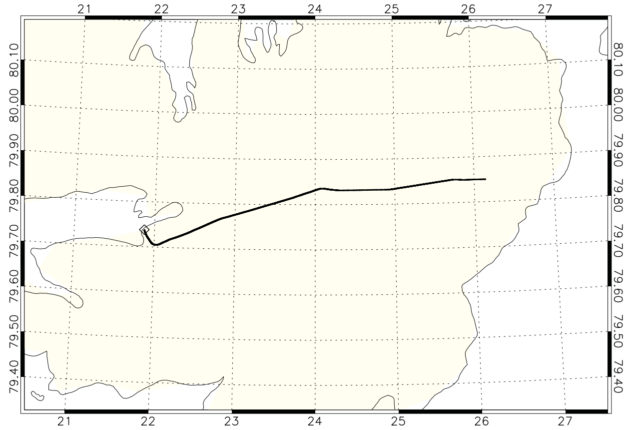


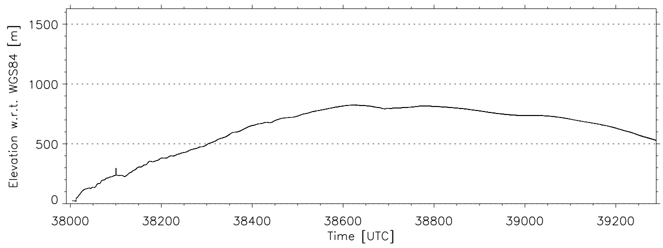


Date	2012-04-28	**Instrument Mode**	Adv. Low Altitude
Start Time	10:29:05 (37745)	**Aircraft**	DNSC Twin Otter
Stop Time	10:31:12 (37872)	**Retracker**	OCOG
Distance	8.576 km	**INS Resolution**	50 Hz
Duration	00 h 02 m 07 s	**Processor Version**	0403

A120428_03

AS30A03_ASIWL1B040320120428T103312_20120428T105450_0001.DBL

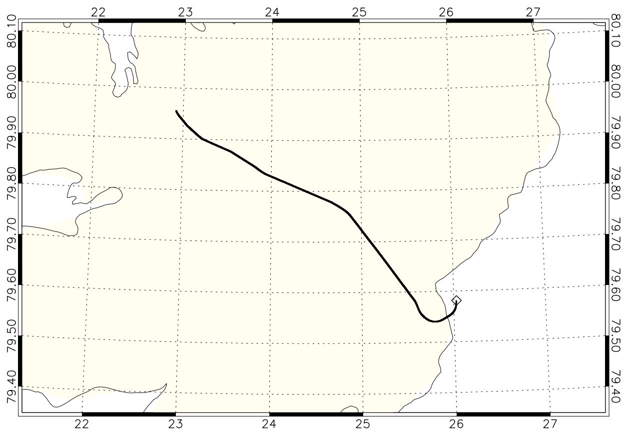


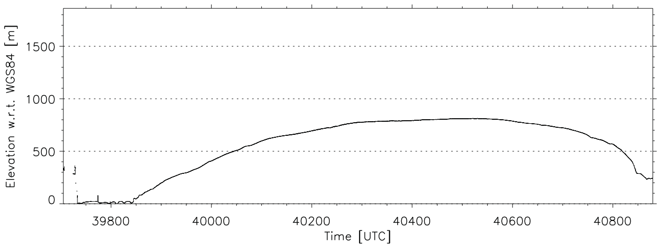


Date	2012-04-28	**Instrument Mode**	Adv. Low Altitude
Start Time	10:33:11 (37991)	**Aircraft**	DNSC Twin Otter
Stop Time	10:54:48 (39288)	**Retracker**	OCOG
Distance	88.810 km	**INS Resolution**	50 Hz
Duration	00 h 21 m 38 s	**Processor Version**	0403

A120428_04

AS30A04_ASIWL1B040320120428T110146_20120428T112121_0001.DBL

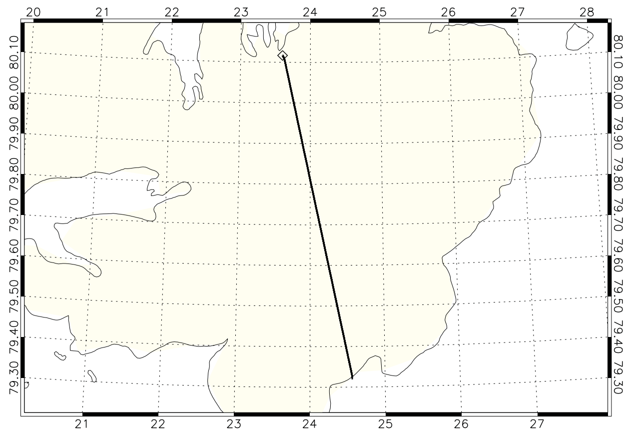


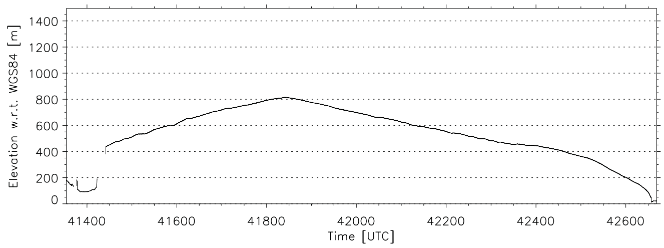


Date	2012-04-28	**Instrument Mode**	Adv. Low Altitude
Start Time	11:01:45 (39705)	**Aircraft**	DNSC Twin Otter
Stop Time	11:21:19 (40879)	**Retracker**	OCOG
Distance	82.750 km	**INS Resolution**	50 Hz
Duration	00 h 19 m 35 s	**Processor Version**	0403

A120428_05

AS30A05_ASIWL1B040320120428T112915_20120428T115110_0001.DBL

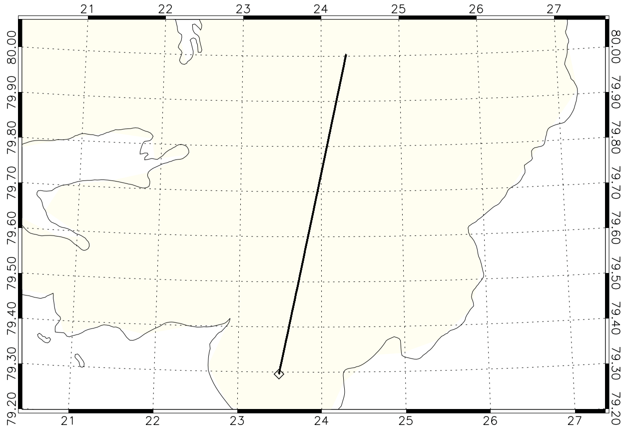


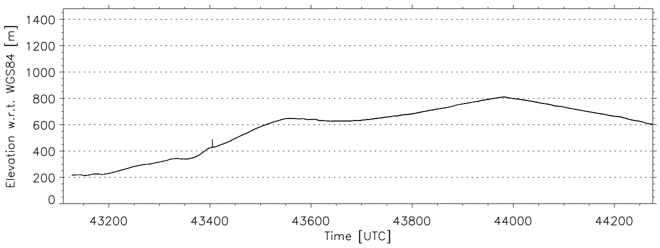


Date	2012-04-28	**Instrument Mode**	Adv. Low Altitude
Start Time	11:29:14 (41354)	**Aircraft**	DNSC Twin Otter
Stop Time	11:51:08 (42668)	**Retracker**	OCOG
Distance	90.632 km	**INS Resolution**	50 Hz
Duration	00 h 21 m 55 s	**Processor Version**	0403

A120428_06

AS30A06_ASIWL1B040320120428T115831_20120428T121757_0001.DBL

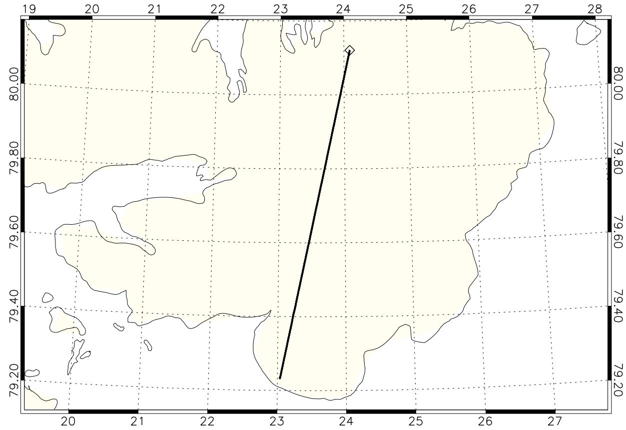


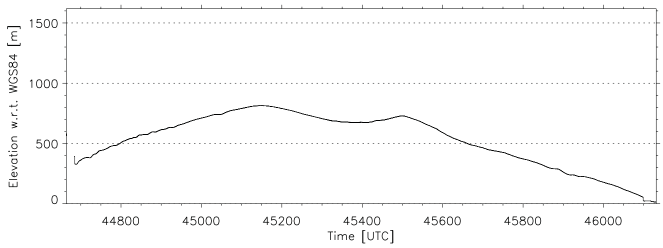


Date	2012-04-28	**Instrument Mode**	Adv. Low Altitude
Start Time	11:58:30 (43110)	**Aircraft**	DNSC Twin Otter
Stop Time	12:17:55 (44275)	**Retracker**	OCOG
Distance	80.383 km	**INS Resolution**	50 Hz
Duration	00 h 19 m 26 s	**Processor Version**	0403

A120428_07

AS30A07_ASIWL1B040320120428T122425_20120428T124852_0001.DBL

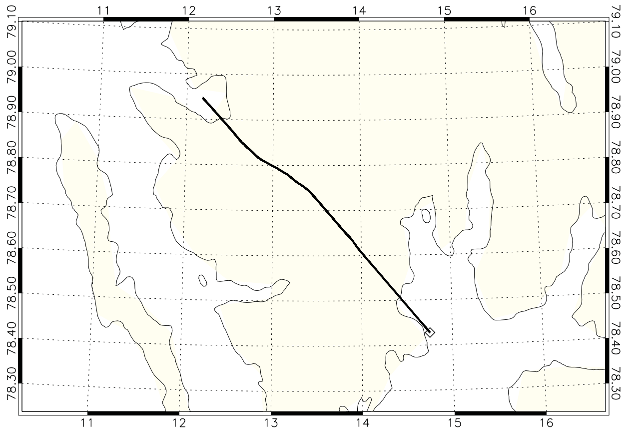


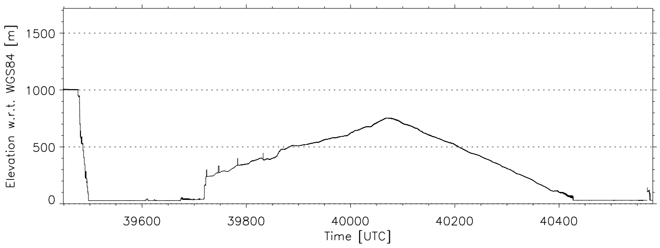


Date	2012-04-28	**Instrument Mode**	Adv. Low Altitude
Start Time	12:24:24 (44664)	**Aircraft**	DNSC Twin Otter
Stop Time	12:48:51 (46131)	**Retracker**	OCOG
Distance	100.950 km	**INS Resolution**	50 Hz
Duration	00 h 24 m 27 s	**Processor Version**	0403

A120429_00

AS30A00_ASIWL1B040320120429T105729_20120429T111620_0001.DBL

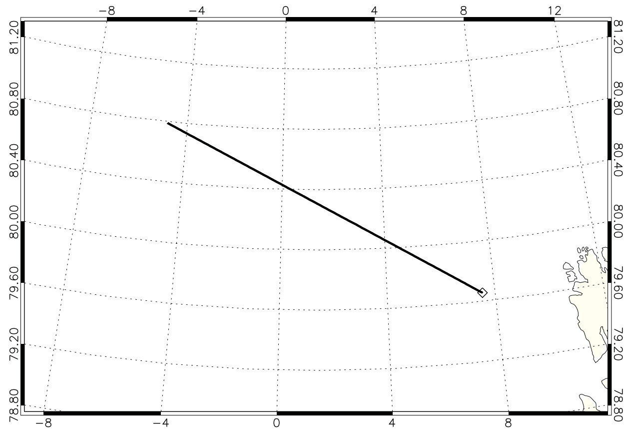


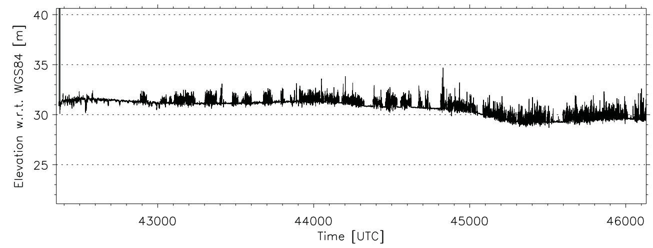


Date	2012-04-29	**Instrument Mode**	Adv. Low Altitude
Start Time	10:57:29 (39449)	**Aircraft**	DNSC Twin Otter
Stop Time	11:16:19 (40579)	**Retracker**	OCOG
Distance	81.219 km	**INS Resolution**	50 Hz
Duration	00 h 18 m 51 s	**Processor Version**	0403

A120429_01

AS30A01_ASIWL1B040320120429T114550_20120429T124851_0001.DBL

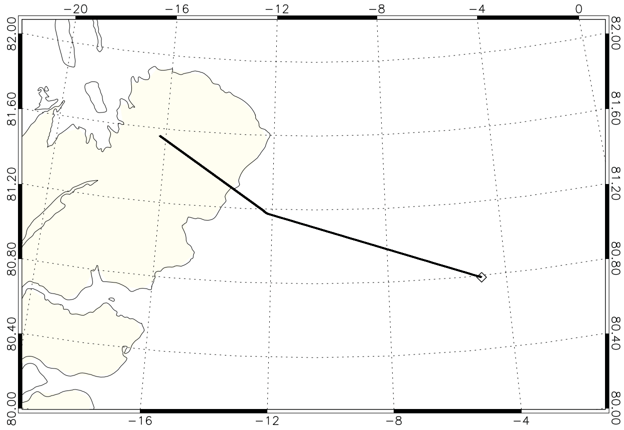


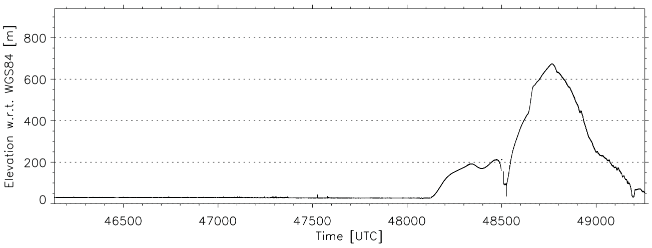


Date	2012-04-29	**Instrument Mode**	Adv. Low Altitude
Start Time	11:45:50 (42350)	**Aircraft**	DNSC Twin Otter
Stop Time	12:48:50 (46130)	**Retracker**	OCOG
Distance	263.883 km	**INS Resolution**	50 Hz
Duration	01 h 03 m 01 s	**Processor Version**	0403

A120429_02

AS30A02_ASIWL1B040320120429T124855_20120429T134057_0001.DBL

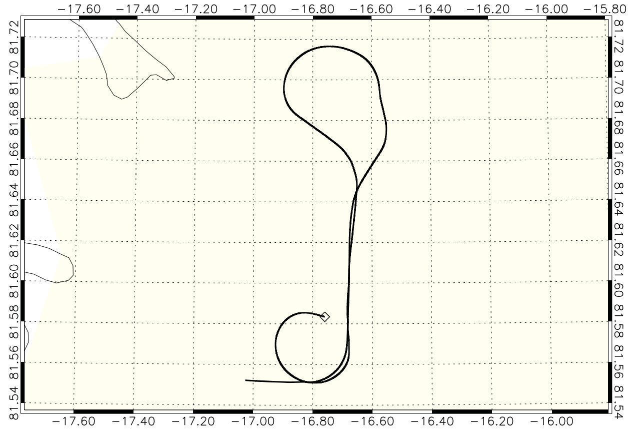


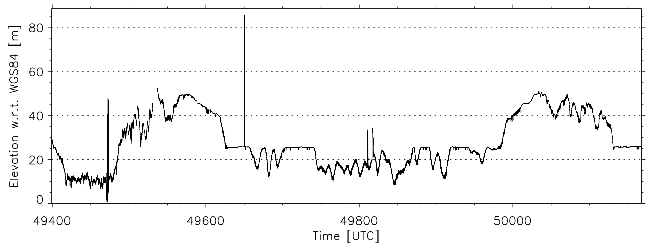


Date	2012-04-29	**Instrument Mode**	Adv. Low Altitude
Start Time	12:48:55 (46135)	**Aircraft**	DNSC Twin Otter
Stop Time	13:40:57 (49257)	**Retracker**	OCOG
Distance	214.931 km	**INS Resolution**	50 Hz
Duration	00 h 52 m 02 s	**Processor Version**	0403

A120429_03

AS30A03_ASIWL1B040320120429T134319_20120429T135608_0001.DBL

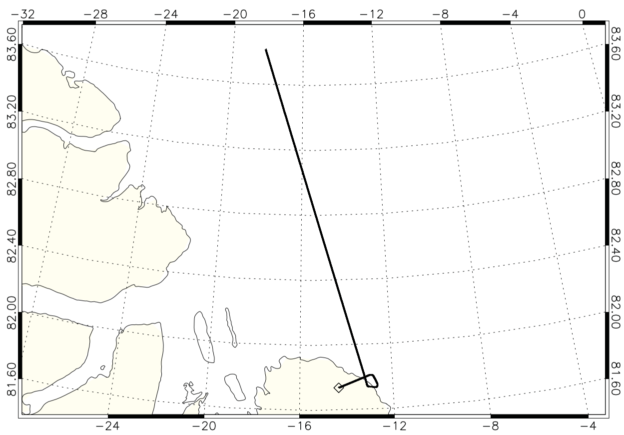


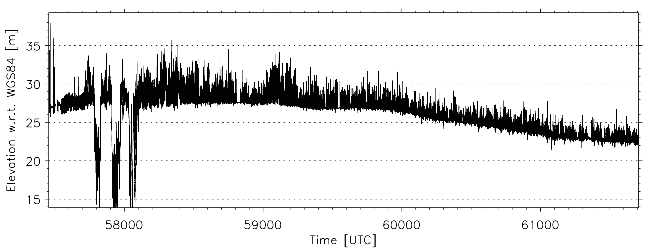


Date	2012-04-29	**Instrument Mode**	Adv. Low Altitude
Start Time	13:43:19 (49399)	**Aircraft**	DNSC Twin Otter
Stop Time	13:56:07 (50167)	**Retracker**	OCOG
Distance	55.046 km	**INS Resolution**	50 Hz
Duration	00 h 12 m 49 s	**Processor Version**	0403

A120429_04

AS30A04_ASIWL1B040320120429T155734_20120429T170827_0001.DBL

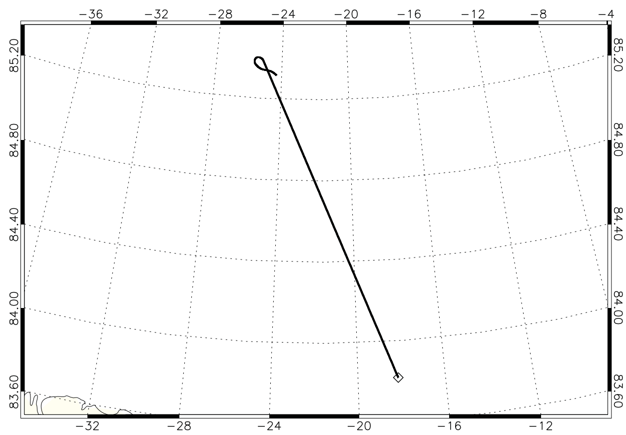


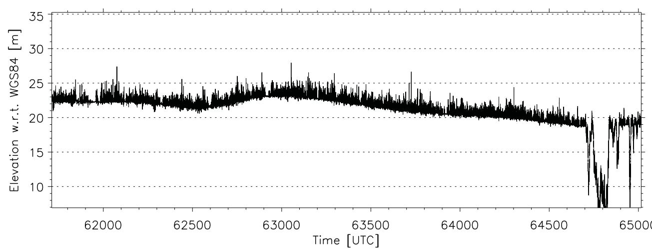


Date	2012-04-29	**Instrument Mode**	Adv. Low Altitude
Start Time	15:57:34 (57454)	**Aircraft**	DNSC Twin Otter
Stop Time	17:08:26 (61706)	**Retracker**	OCOG
Distance	281.057 km	**INS Resolution**	50 Hz
Duration	01 h 10 m 53 s	**Processor Version**	0403

A120429_05

AS30A05_ASIWL1B040320120429T170831_20120429T180336_0001.DBL

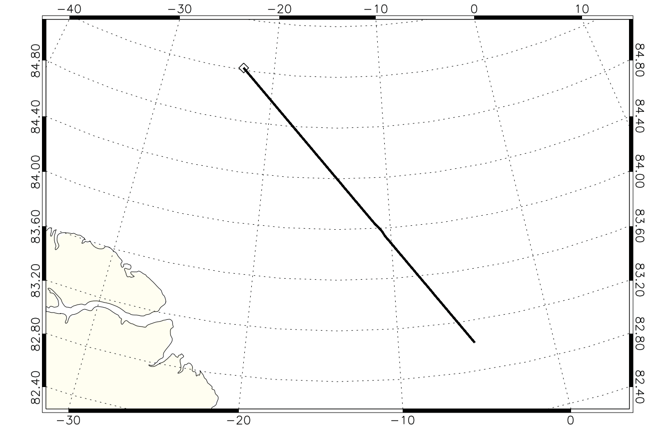


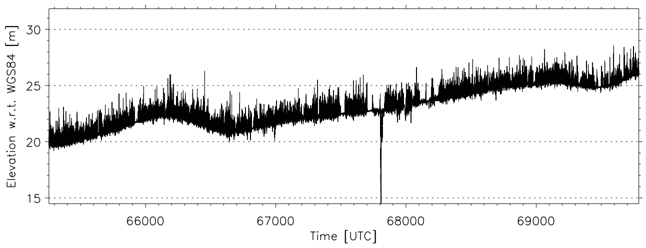


Date	2012-04-29	**Instrument Mode**	Adv. Low Altitude
Start Time	17:08:31 (61711)	**Aircraft**	DNSC Twin Otter
Stop Time	18:03:35 (65015)	**Retracker**	OCOG
Distance	210.951 km	**INS Resolution**	50 Hz
Duration	00 h 55 m 05 s	**Processor Version**	0403

A120429_06

AS30A06_ASIWL1B040320120429T180738_20120429T192308_0001.DBL

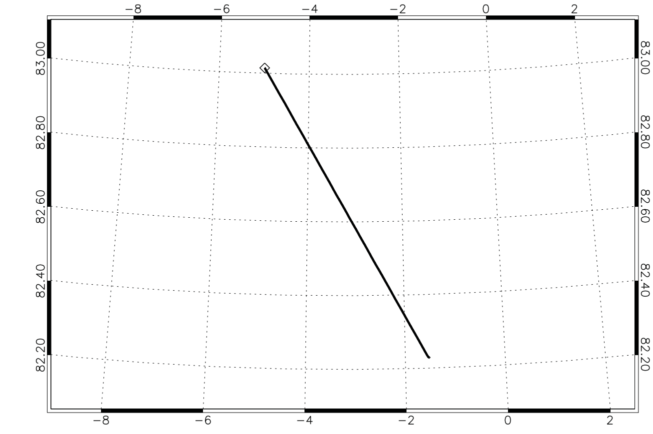


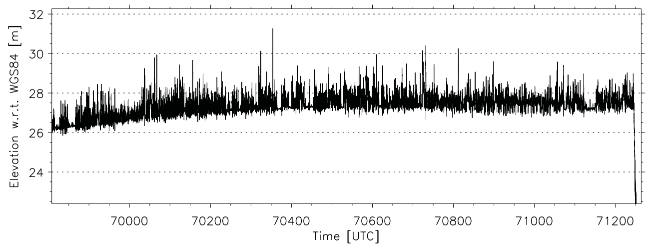


Date	2012-04-29	**Instrument Mode**	Adv. Low Altitude
Start Time	18:07:38 (65258)	**Aircraft**	DNSC Twin Otter
Stop Time	19:23:07 (69787)	**Retracker**	OCOG
Distance	314.666 km	**INS Resolution**	50 Hz
Duration	01 h 15 m 30 s	**Processor Version**	0403

A120429_07

AS30A07_ASIWL1B040320120429T192328_20120429T194744_0001.DBL

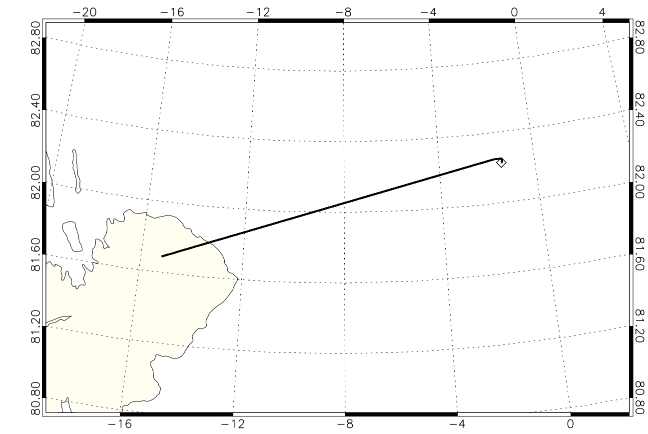


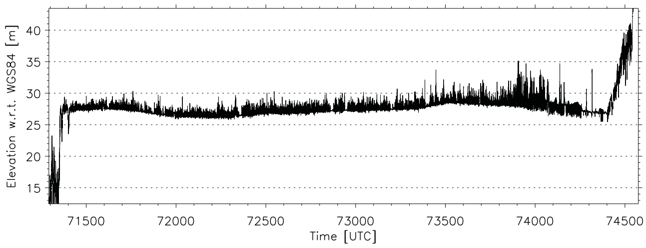


Date	2012-04-29	**Instrument Mode**	Adv. Low Altitude
Start Time	19:23:28 (69808)	**Aircraft**	DNSC Twin Otter
Stop Time	19:47:43 (71263)	**Retracker**	OCOG
Distance	100.541 km	**INS Resolution**	50 Hz
Duration	00 h 24 m 16 s	**Processor Version**	0403

A120429_08

AS30A08_ASIWL1B040320120429T194812_20120429T204255_0001.DBL

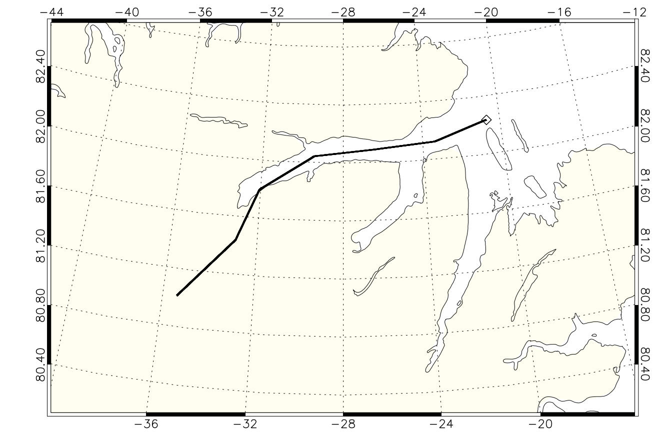


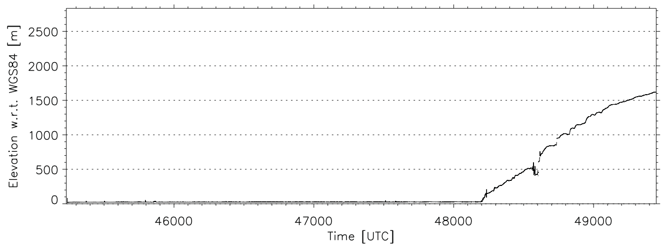


Date	2012-04-29	**Instrument Mode**	Adv. Low Altitude
Start Time	19:48:12 (71292)	**Aircraft**	DNSC Twin Otter
Stop Time	20:42:54 (74574)	**Retracker**	OCOG
Distance	225.645 km	**INS Resolution**	50 Hz
Duration	00 h 54 m 42 s	**Processor Version**	0403

A120501_00

AS30A00_ASIWL1B040320120501T123350_20120501T134408_0001.DBL

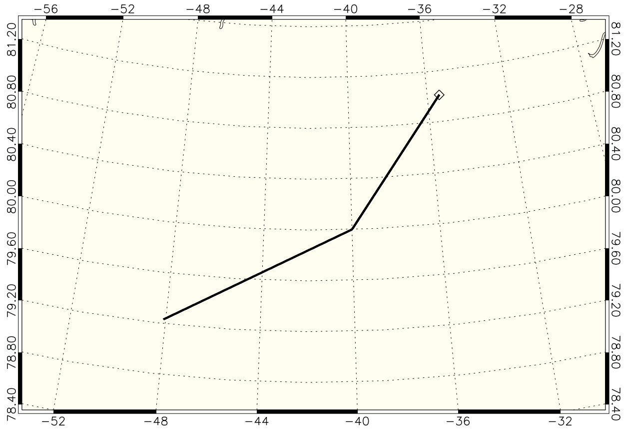


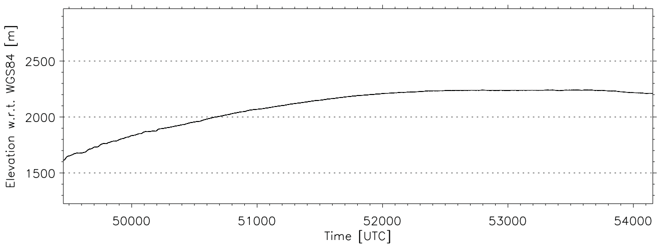


Date	2012-05-01	**Instrument Mode**	Adv. Low Altitude
Start Time	12:33:50 (45230)	**Aircraft**	DNSC Twin Otter
Stop Time	13:44:07 (49447)	**Retracker**	OCOG
Distance	290.286 km	**INS Resolution**	50 Hz
Duration	01 h 10 m 18 s	**Processor Version**	0403

A120501_01

AS30A01_ASIWL1B040320120501T134415_20120501T150235_0001.DBL

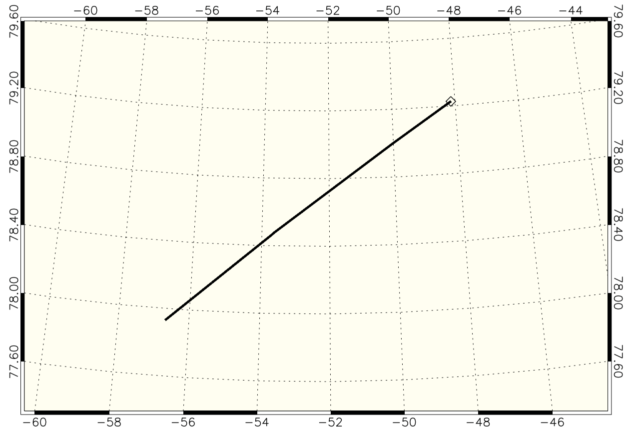


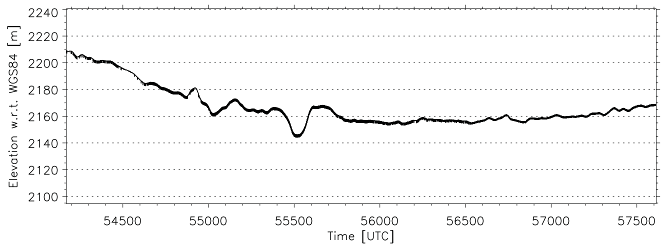


Date	2012-05-01	**Instrument Mode**	Adv. Low Altitude
Start Time	13:44:15 (49455)	**Aircraft**	DNSC Twin Otter
Stop Time	15:02:35 (54155)	**Retracker**	OCOG
Distance	322.687 km	**INS Resolution**	50 Hz
Duration	01 h 18 m 20 s	**Processor Version**	0403

A120501_02

AS30A02_ASIWL1B040320120501T150250_20120501T160013_0001.DBL

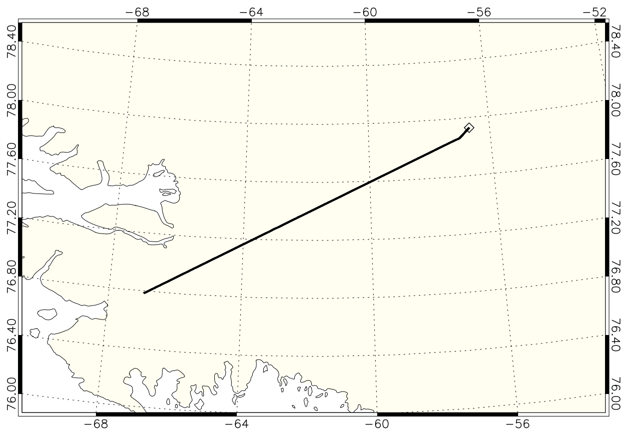


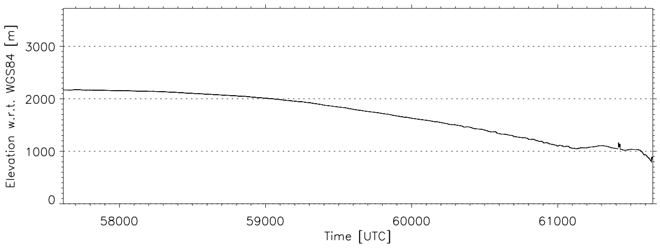


Date	2012-05-01	**Instrument Mode**	Adv. Low Altitude
Start Time	15:02:50 (54170)	**Aircraft**	DNSC Twin Otter
Stop Time	16:00:12 (57612)	**Retracker**	OCOG
Distance	236.732 km	**INS Resolution**	50 Hz
Duration	00 h 57 m 23 s	**Processor Version**	0403

A120501_03

AS30A03_ASIWL1B040320120501T160016_20120501T170731_0001.DBL

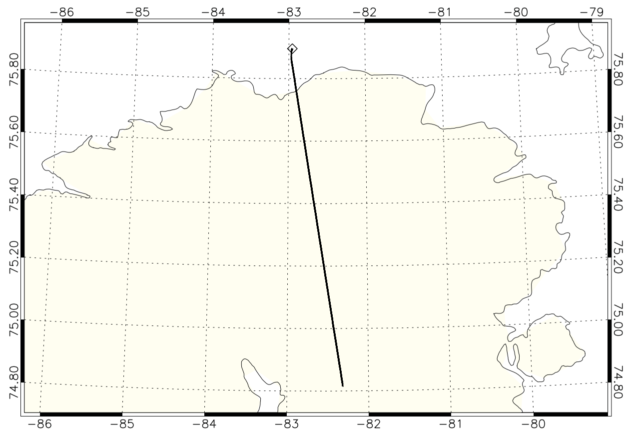


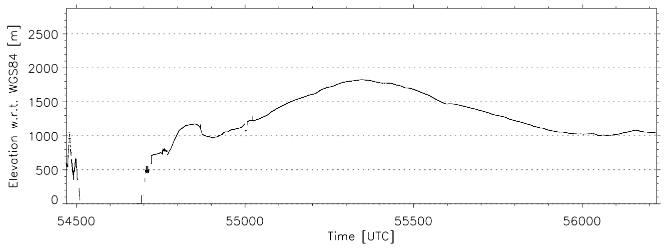


Date	2012-05-01	**Instrument Mode**	Adv. Low Altitude
Start Time	16:00:16 (57616)	**Aircraft**	DNSC Twin Otter
Stop Time	17:07:30 (61650)	**Retracker**	OCOG
Distance	280.394 km	**INS Resolution**	50 Hz
Duration	01 h 07 m 15 s	**Processor Version**	0403

A120503_00

AS30A00_ASIWL1B040320120503T150750_20120503T153701_0001.DBL

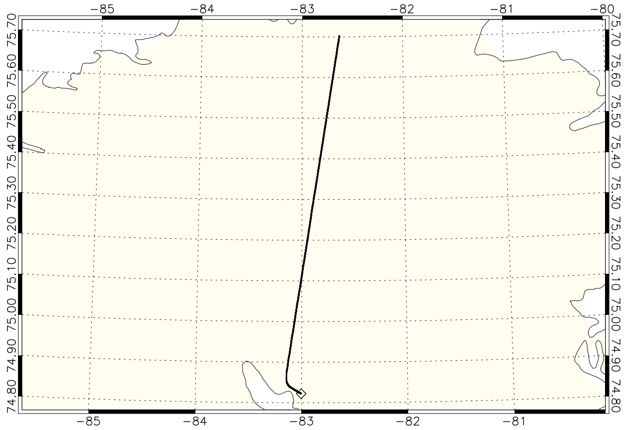


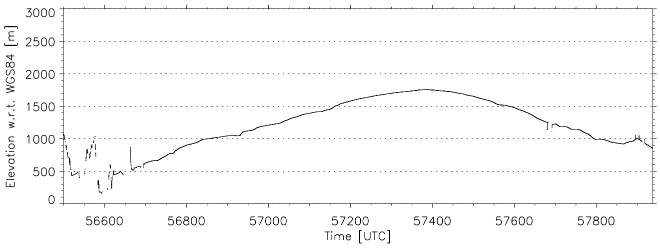


Date	2012-05-03	**Instrument Mode**	Adv. Low Altitude
Start Time	15:07:50 (54470)	**Aircraft**	DNSC Twin Otter
Stop Time	15:37:00 (56220)	**Retracker**	OCOG
Distance	121.883 km	**INS Resolution**	50 Hz
Duration	00 h 29 m 11 s	**Processor Version**	0403

A120503_01

AS30A01_ASIWL1B040320120503T154139_20120503T160538_0001.DBL

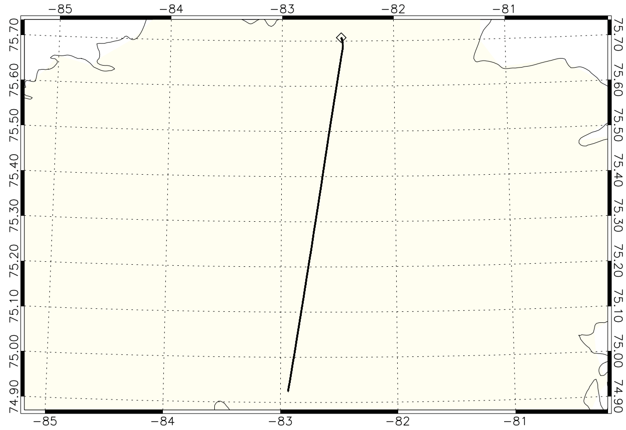


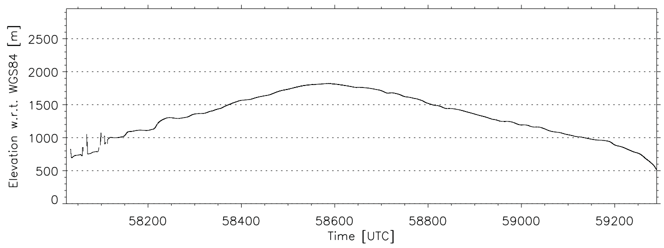


Date	2012-05-03	**Instrument Mode**	Adv. Low Altitude
Start Time	15:41:39 (56499)	**Aircraft**	DNSC Twin Otter
Stop Time	16:05:37 (57937)	**Retracker**	OCOG
Distance	101.353 km	**INS Resolution**	50 Hz
Duration	00 h 23 m 58 s	**Processor Version**	0403

A120503_02

AS30A02_ASIWL1B040320120503T160705_20120503T162810_0001.DBL

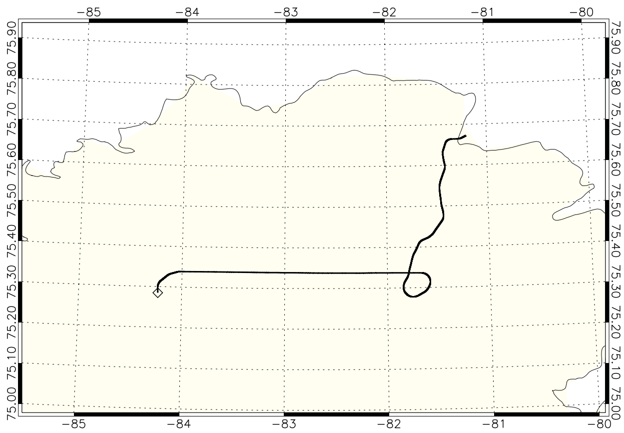


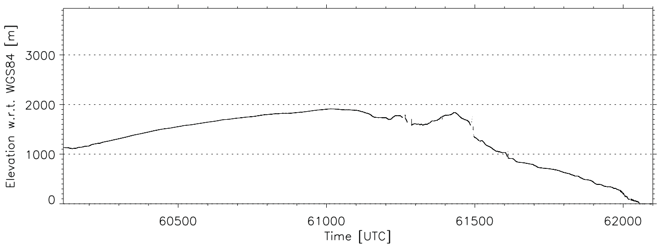


Date	2012-05-03	**Instrument Mode**	Adv. Low Altitude
Start Time	16:07:05 (58025)	**Aircraft**	DNSC Twin Otter
Stop Time	16:28:09 (59289)	**Retracker**	OCOG
Distance	88.378 km	**INS Resolution**	50 Hz
Duration	00 h 21 m 05 s	**Processor Version**	0403

A120503_03

AS30A03_ASIWL1B040320120503T164153_20120503T171500_0001.DBL

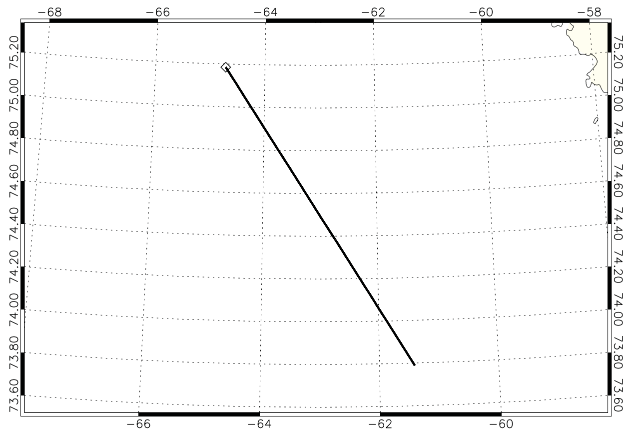


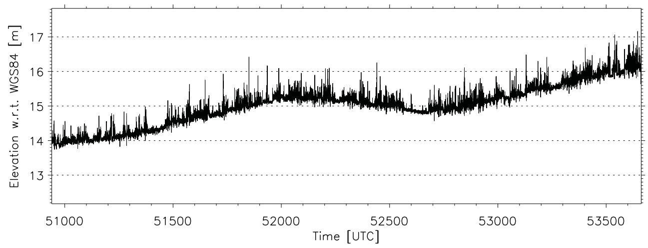


Date	2012-05-03	**Instrument Mode**	Adv. Low Altitude
Start Time	16:41:53 (60113)	**Aircraft**	DNSC Twin Otter
Stop Time	17:14:59 (62099)	**Retracker**	OCOG
Distance	140.748 km	**INS Resolution**	50 Hz
Duration	00 h 33 m 07 s	**Processor Version**	0403

A120504_00

AS30A00_ASIWL1B040320120504T140900_20120504T145422_0001.DBL

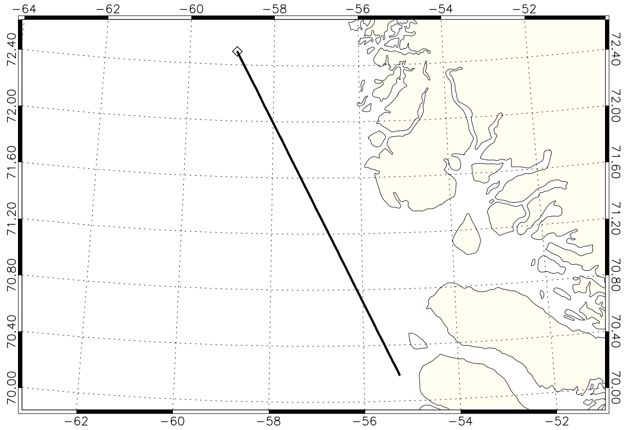


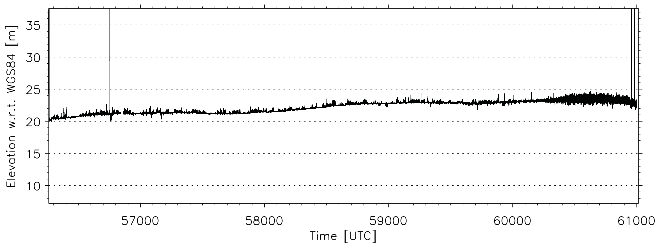


Date	2012-05-04	**Instrument Mode**	Adv. Low Altitude
Start Time	14:09:00 (50940)	**Aircraft**	DNSC Twin Otter
Stop Time	14:54:21 (53661)	**Retracker**	OCOG
Distance	183.492 km	**INS Resolution**	50 Hz
Duration	00 h 45 m 22 s	**Processor Version**	0403

A120504_01

AS30A01_ASIWL1B040320120504T153740_20120504T165655_0001.DBL

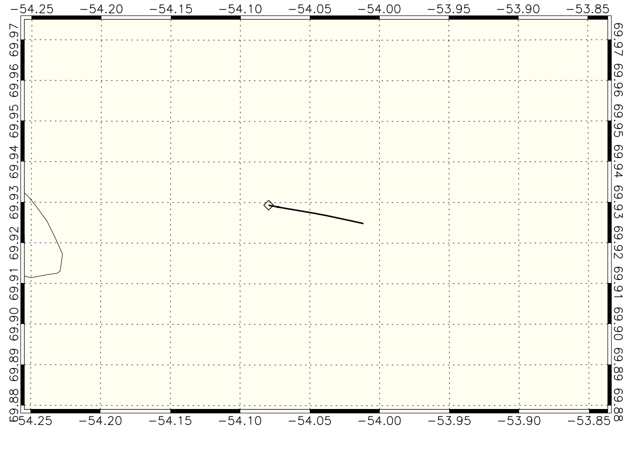


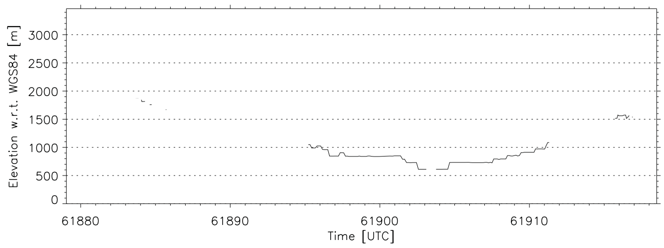


Date	2012-05-04	**Instrument Mode**	Adv. Low Altitude
Start Time	15:37:40 (56260)	**Aircraft**	DNSC Twin Otter
Stop Time	16:56:54 (61014)	**Retracker**	OCOG
Distance	287.360 km	**INS Resolution**	50 Hz
Duration	01 h 19 m 15 s	**Processor Version**	0403

A120504_02

AS30A02_ASIWL1B040320120504T171119_20120504T171159_0001.DBL

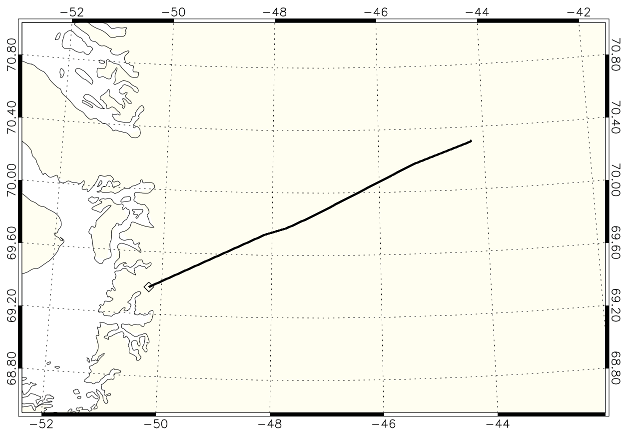


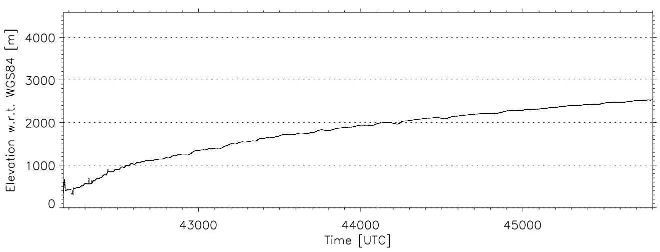


Date	2012-05-04	**Instrument Mode**	Adv. Low Altitude
Start Time	17:11:19 (61879)	**Aircraft**	DNSC Twin Otter
Stop Time	17:11:58 (61918)	**Retracker**	OCOG
Distance	2.657 km	**INS Resolution**	50 Hz
Duration	00 h 00 m 39 s	**Processor Version**	0403

A120505_00

AS30A00_ASIWL1B040320120505T114246_20120505T124322_0001.DBL

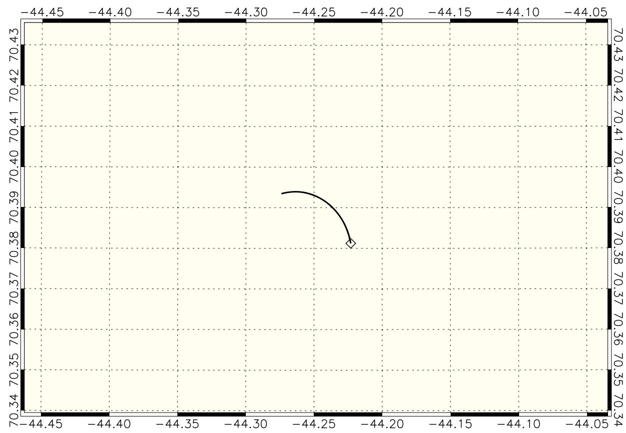


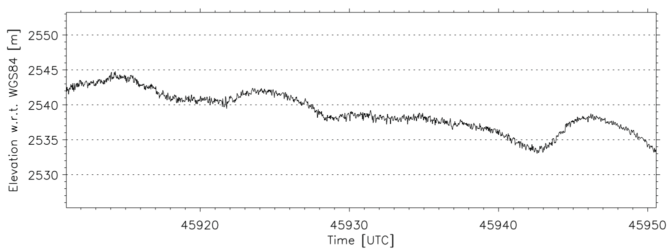


Date	2012-05-05	**Instrument Mode**	Adv. Low Altitude
Start Time	11:42:46 (42166)	**Aircraft**	DNSC Twin Otter
Stop Time	12:43:21 (45801)	**Retracker**	OCOG
Distance	252.877 km	**INS Resolution**	50 Hz
Duration	01 h 00 m 35 s	**Processor Version**	0403

A120505_01

AS30A01_ASIWL1B040320120505T124511_20120505T124551_0001.DBL

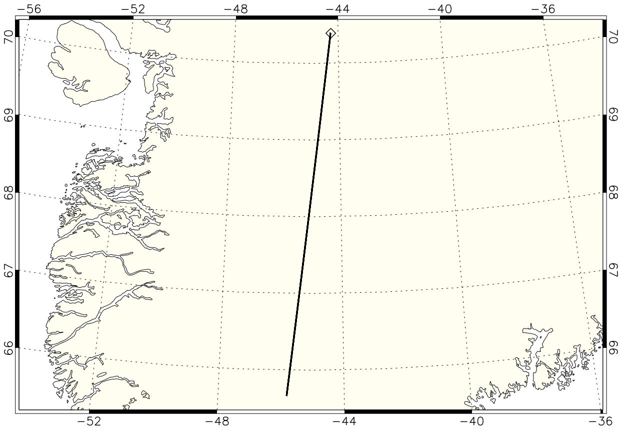


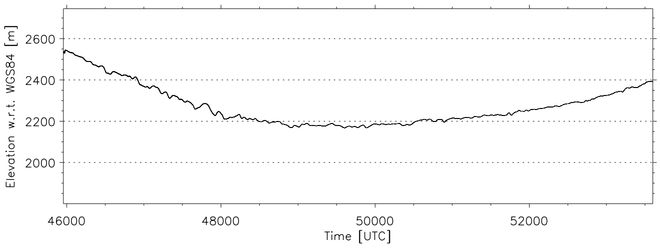


Date	2012-05-05	**Instrument Mode**	Adv. Low Altitude
Start Time	12:45:11 (45911)	**Aircraft**	DNSC Twin Otter
Stop Time	12:45:50 (45950)	**Retracker**	OCOG
Distance	2.635 km	**INS Resolution**	50 Hz
Duration	00 h 00 m 40 s	**Processor Version**	0403

A120505_02

AS30A02_ASIWL1B040320120505T124556_20120505T145322_0001.DBL

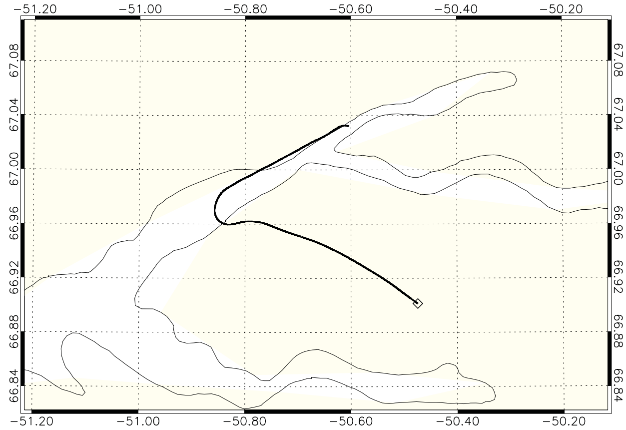


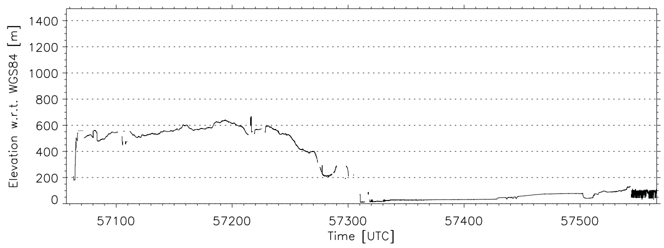


Date	2012-05-05	**Instrument Mode**	Adv. Low Altitude
Start Time	12:45:56 (45956)	**Aircraft**	DNSC Twin Otter
Stop Time	14:53:21 (53601)	**Retracker**	OCOG
Distance	529.019 km	**INS Resolution**	50 Hz
Duration	02 h 07 m 26 s	**Processor Version**	0403

A120505_03

AS30A03_ASIWL1B040320120505T155057_20120505T155926_0001.DBL





Date	2012-05-05	**Instrument Mode**	Adv. Low Altitude
Start Time	15:50:57 (57057)	**Aircraft**	DNSC Twin Otter
Stop Time	15:59:26 (57566)	**Retracker**	OCOG
Distance	32.849 km	**INS Resolution**	50 Hz
Duration	00 h 08 m 29 s	**Processor Version**	0403

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